GEOLOGICAL SURVEY OF CANADA
BULLETIN 389

TRILOBITES FROM THE SURVEY PEAK, OUTRAM AND SKOKI FORMATIONS (UPPER CAMBRIAN – LOWER ORDOVICIAN) AT WILCOX PASS, JASPER NATIONAL PARK, ALBERTA

W. T. Dean

1989

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90-02314/

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Available in Canada through

authorized bookstore agents and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Ottawa, Canada K1A 0S9

and from

Geological Survey of Canada offices:

601 Booth Street
Ottawa, Canada K1A 0E8

3303-33rd Street N.W.,
Calgary, Alberta T2L 2A7

A deposit copy of this publication is also available for reference
in public libraries across Canada

Cat. No. M42-389E
ISBN 0-660-13421-7

Price subject to change without notice

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Original manuscript received: 87.03.09
Final version approved for publication: 88.02.18

PREFACE

The trilobites from the Upper Cambrian to Lower Ordovician Survey Peak, Outram and Skoki formations at Wilcox Pass, Alberta, comprehensively described in this report, belong to 48 genera. One new genus and six new species are described, and type material for seventeen previously described species from corresponding strata elsewhere in the Rockies is redescribed or re-illustrated.

This report establishes a biostratigraphic framework for the Wilcox Pass sequence, from the highest part of the Upper Cambrian Trempealeau Series through the entire Lower Ordovician, based on trilobite zones. Some evidence of diachronism between the succession at Wilcox Pass and strata in areas to the south is demonstrated.

Detailed taxonomic studies such as this provide the foundation for precise dating and correlation of rock units, and are essential for the continuing refinement of biostratigraphic zonation that is crucial to assessments of resources contained in Canada's sedimentary basins.

Elkanah A. Babcock
Assistant Deputy Minister
Geological Survey of Canada

PRÉFACE

Sur les lieux du col Wilcox (Alberta), on a trouvé des trilobites dans les formations de Survey Peak, d'Outram et de Skoki qui vont du Cambrien supérieur à l'Ordovicien inférieur. Ces trilobites, décrits en détail dans le présent rapport, appartiennent à 48 genres. Un nouveau genre et six nouvelles espèces sont décrits, tandis qu'est décrit ou illustré de nouveau le matériau type de 17 espèces antérieurement décrites et provenant de couches géologiques situées ailleurs dans les Rocheuses.

Le rapport établit un cadre biostratigraphique pour la succession du col de Wilcox, à partir de la partie la plus élevée de la série de Trempealeau du Cambrien supérieur pendant toute la durée de l'Ordovicien inférieur, d'après des zones de trilobites. On apporte quelques preuves de diachronisme entre la succession du col de Wilcox et certaines couches géologiques rencontrées dans des secteurs plus au sud.

Des études taxonomiques comme celle-ci fournissent le fondement d'une géochronologie et d'une corrélation précises des unités lithostratigraphiques et sont essentielles au raffinement continu de la zonation biostratigraphique, cette démarche étant de première importance dans l'évaluation des ressources appartenant aux bassins sédimentaires du Canada.

Elkanah A. Babcock
Sous-ministre adjoint
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TRILOBITES FROM THE SURVEY PEAK, OUTRAM AND SKOKI FORMATIONS (UPPER CAMBRIAN - LOWER ORDOVICIAN) AT WILCOX PASS, JASPER NATIONAL PARK, ALBERTA

Abstract

Trilobites belonging to 48 genera and subgenera are described from 148 levels in 630 m of strata constituting the Survey Peak and Outram formations and in the basal 6.4 m of the Skoki Formation at Wilcox Pass, 95 km southeast of Jasper, Alberta. A number of taxa from the McKay Group of adjacent British Columbia, originally described by Kobayashi (1955) are reassessed. Range charts show the vertical distribution of taxa and a correlation is proposed with the highest part of the Trempealeau Series, and with zones A to J established in Utah. New taxa include *Carinocranium cariniferum* n. gen. et sp., and the following new species: *Apatokephalus? longifrons*, *Aulacoparia (Aulacoparia) sculpta*, *Benthamaspis canadensis*, *Isoteloides saxosimontis*, *Menoparia elegans*, *Pliomeridius lacunatus*, and *Presbynileus (Presbynileus) latifrons*. Type material of the following species is redescribed or reillustrated: *Corbinia horatio* Walcott, 1924, *Corbinia valida* Walcott, 1925, *Crepicephalus ceratopygoides* Raymond, 1925, *Dicellocephalus finalis* Walcott, 1884, *Dicellocephalus? flagricaudus* White, 1874, *Gonioteloides monoceros* Kobayashi, 1955, *Hungaia billingsi* Walcott, 1924, *Hyperbolochilus expansus* Kobayashi, 1955, *Leiostegium (Evansaspis) glabrum* Kobayashi, 1955, *Neoagnostus aspidoides* Kobayashi, 1955, *Paenebeltella convexa* Kobayashi, 1955, *Protopliomerops radiatus* Kobayashi, 1955, *Protopliomerops subquadratus* Kobayashi, 1955, *Ptychoparia? annectans* Walcott, 1884, *Symphysurina walcotti* Kindle, 1929, *Tesselacauda flabella* Kobayashi, 1955, and *Vermilionites bisulcatus* Kobayashi, 1955; some of these are now assigned to different genera and species.

Résumé

Dans le présent article, sont décrits des trilobites appartenant à 48 genres et sous-genres et provenant de 148 niveaux à l'intérieur des 630 m de strates qui constituent les formations de Survey Peak et d'Outram, et à l'intérieur des 6,4 premiers mètres de la base de la formation de Skoki au col Wilcox, à 95 km au sud-est de Jasper en Alberta. On procède actuellement à un nouvel examen d'un certain nombre de taxons provenant du groupe de McKay situé dans la province voisine (Colombie-Britannique), et initialement décrits par Kobayashi (1955). Les diagrammes d'intervalles biostratigraphiques montrent la distribution verticale des taxons; on propose d'établir une corrélation entre la partie sommitale des séries de Trempealeau et les zones A à J identifiées dans l'Utah. Les nouveaux taxons comprennent *Carinocranium cariniferum* n. gen. et sp., et les nouvelles espèces suivantes : *Apatokephalus? longifrons*, *Aulacoparia (Aulacoparia) sculpta*, *Benthamaspis canadensis*, *Isoteloides saxosimontis*, *Menoparia elegans*, *Pliomeridius lacunatus*, et *Presbynileus (Presbynileus) latifrons*. Les spécimens typés des espèces suivantes sont à nouveau décrits ou illustrés : *Corbinia horatio* Walcott, 1924, *Corbinia valida* Walcott, 1925, *Crepicephalus ceratopygoides* Raymond, 1925, *Dicellocephalus finalis* Walcott, 1884, *Dicellocephalus? flagricaudus* White, 1874, *Gonioteloides monoceros* Kobayashi, 1955, *Hungaia billingsi* Walcott, 1924, *Hyperbolochilus expansus* Kobayashi, 1955, *Leiostegium (Evansaspis) glabrum* Kobayashi, 1955, *Neoagnostus aspidoides* Kobayashi, 1955, *Paenebeltella convexa* Kobayashi, 1955, *Protopliomerops radiatus* Kobayashi, 1955, *Protopliomerops subquadratus* Kobayashi, 1955, *Ptychoparia? annectans* Walcott, 1884, *Symphysurina walcotti* Kindle, 1929, *Tesselacauda flabella* Kobayashi, 1955, et *Vermilionites bisulcatus* Kobayashi, 1955; quelques-uns de ces spécimens sont maintenant placés dans d'autres classifications de genres et d'espèces.

Summary

Trilobites are described from the Survey Peak Formation, Outram Formation and the basal 6.4 m of the Skoki Formation at Wilcox Pass, southern Canadian Rocky Mountains. In addition a number of previously described species from corresponding strata elsewhere in the Canadian Rockies and western U.S.A., and from the McKay Group of British Columbia are redescribed. Forty-eight named genera, belonging to twenty-one families, are included; their age ranges from latest Late Cambrian (Trempealeau Series, in part) to Early Ordovician (Ibex Series, in part). Not all the strata yielded trilobites, but it was possible to use the system of trilobite zones proposed by Ross (1949, 1951) and by Hintze (1953) for successions in Utah and Nevada. No graptolites of zonal value have been found at Wilcox Pass and correlation with successions in England, Wales and Scandinavia must be considered provisional.

One new genus and six new species are described: *Carinocranium* and its type species, *C. cariniferum* and *Aulacoparia (Aulacoparia) sculpta*, *Benthamaspis canadensis*, *Isoteloides saxosimontis*, *Presbynileus (Presbynileus) latifrons* and *Pliomeridius lacunatus*.

The Survey Peak Formation, 357.5 m thick, is divided into four informal members. Those are successively: basal silty member, 42 m; putty shale member, 38 m; middle member, 199 m; and upper massive member, 78.5 m. The rocks comprise shallow marine strata deposited between the middle carbonate and outer detrital belts near the margin of Laurentia. All the members have gradational boundaries, and there is some evidence of diachronism between Wilcox Pass and Mount Wilson, 35 km to the southeast, where the units were established. The basal silty member consists mainly of calcareous siltstone with minor interbeds of mudstone, and numerous, impersistent beds of conglomerate and thrombolitic limestone. The oldest trilobites belong to the *Corbinia apopsis* Subzone of the *Saukia* Zone, and include *Corbinia horatio*, *Apatokephaloides clivosus* and *Plethometopus obtusus*. *Apoplanias rejectus* extends higher, into the lower part of the *Missisquoia* Zone, the zonal index of which is uncommon here. In the higher part of the *Missisquoia* Zone are *Highgatella*? *cordilleri* and *Symphysurina*, both of which range into Zone A. The top of the *Missisquoia* Zone is drawn arbitrarily at the highest record of the eponymous genus. Zone A trilobites in the higher part of the basal silty member include *Geragnostus (Micragnostus) chiushuensis*, *Symphysurina*, the last representatives of *H.*? *cordilleri*, and the earliest examples of *Clelandia albertensis* and *Jujuyaspis borealis*.

Macrofossils are virtually absent from the green-grey mudstone that makes up most of the putty shale member, but thin beds of calcareous siltstone, some of them conglomeratic, yielded *G. (M.) chiushuensis*, *J. borealis*, *Clelandia albertensis* and *Symphysurina*, all of which range from the basal silty member. The base of Zone B is defined by the appearance of *Bellefontia*, represented by *B. nonius*.

The middle member, though 199 m thick, contains varied trilobites only in the highest 43 m. The lowest sixth of the member is dated as Zone B by means of *Bellefontia* and *Parabellefontia*, and the limits of Zone D are defined by the vertical range of *Kainella billingsi*. No trilobites were found in the intervening strata, which are assigned arbitrarily to Zone C, a unit poorly defined in its type area in Utah. The base and top of Zone E are defined by the vertical range of *Paenebeltella convexa*, a species that extends into the lowest part of the upper massive member, as does the abundant *Leiostegium (Evansaspis) ceratopygoides*. Other trilobites characteristic of Zone E in the higher part of the middle member include *Gonioteloides monoceros*, *Hyperbolochilus*, *Pseudoclelandia fluxafissura* and *Tesselacauda flabella*.

Trilobites are uncommon in the thick, often thrombolitic, beds of limestone in the upper massive member, particularly its highest two-thirds. Only the rare Utah species *Pseudoclelandia corrupsittaca* is considered diagnostic of Zone F, the limits of which at Wilcox Pass are defined by the top and base of the underlying and overlying zones. Hystricurids have been found at Wilcox Pass only in zones D and E, and the lower part of Zone F.

The Outram Formation, 266 m thick, represents deeper conditions of deposition and the rock types include, in particular, dark grey mudstone and grey, nodular limestone. Trilobite genera include several asaphaceans, uncommon pliomerids, and the wide-spread, probably pelagic telephinid *Carolinites*. The lowest 4.2 m of the formation lack macrofossils and are assigned arbitrarily to Zone F. Zone G has not proved divisible, as it has in Utah, and its lower and upper limits coincide with those of the vertical range of *Aulacoparia (Aulacoparia) sculpta*. Other trilobites in Zone G are the kainellid *Menoparia elegans* and the ?lecanopygid *Benthamaspis obrepta*, which occurs in Utah and Montana. Zones H and I (undifferentiated) coincide with strata that contain almost no macrofossils, and the base of Zone J is based on the appearance of *Lachnostoma latucelsum*, a Utah species that extends almost to the top of the Outram Formation. Other trilobites in Zone J include *Benthamaspis canadensis*, *B. diminutiva*, *Goniotelina brevis*, *Pliomeridius lacunatus*, *Presbynileus (Presbynileus) latiforns*, *Protopliomerops*? *radiatus*, *Pseudocybele nasuta*, and *Ptyocephalus declevitus*. Most of the Skoki Formation consists of thick bedded dolomite with subsidiary horizons of dark, nodular chert. Trilobites from two thin beds of limestone in the lowest 6.4 m of the formation include species found in the higher Outram Formation, together with *Cybelopsis speciosa*, and indicate Zone J.

Sommaire

L'auteur décrit les trilobites de la Formation de Survey Peak, de la Formation d'Outram et des premiers 6,40 m de la Formation de Skoki au Défilé de Wilcox, dans le sud des Montagnes Rocheuses canadiennes. En outre, certaines espèces connues ailleurs dans les Rocheuses canadiennes, dans l'ouest des Etats-Unis et dans le Groupe McKay, en Colombie Britannique, sont redécrites. Quarante et un genres formellement nommes, appartenant a vingt et un familles, sont reconnus; leur âge va de la fin du Cambrien Supérieur (Série Trempealeau, en partie) au début de l'Ordovicien (Série Ibex, en partie). Bien que tous les dépôts ne contiennent pas des trilobites, il est possible d'utiliser la zonation en lettres proposée par Ross (1949, 1951) et par Hintze (1953) dans l'Utah et le Nevada. Aucun graptolite de valeur stratigraphique n'a été trouvé au Défilé de Wilcox et les corrélations avec l'Angleterre, le Pays de Galles et la Scandinavie sont provisoires.

Un nouveau genre et six nouvelles espèces sont fondés : *Carinocranium* et son espèce-type, *C. cariniferum*, et *Aulacoparia (Aulacoparia) sculpta*, *Benthamaspis canadensis*, *Isoteloides saxosimontis*, *Presbynileus (Presbynileus) latifrons* et *Pliomeridius lacunatus*.

La Formation de Survey Peak, épaisses de 357,50 m, est divisée en quatre membres informels. Ils sont successivement : le membre basal silteux, 42 m; le membre du schiste d'aspect mastic, 38 m; le membre moyen, 199 m, et le membre supérieur massif, 78,50 m. Les roches sont formées de couches marines déposées, à faible profondeur, entre les ceintures carbonatée moyenne et détritique externe. Les transitions entre les membres sont progressives et il existe un certain diachronisme entre les couches du Défilé de Wilcox et celle du Mont Wilson, 35 km au sud-est, où les unités ont été établies pour la première fois. Le membre basal silteux est principalement formé de microgrès calcaires avec des intercalations mineures de pélites et des lits abondants et discontinus de conglomérats et de calcaire à thrombolithes. Les plus anciens trilobites, comprenant *Corbinia horatio*, *Apatokephaloides clivosus* et *Plethometopus obtusus*, appartiennent à la Sous-Zone à *Corbinia apopsis* de la Zone à *Saukia*. *Apoplanias rejectus* est trouvé plus haut, dans la partie inférieure de la Zone à *Missisquoia*, dans laquelle le marqueur de la zone est rare. *Highgatella*? *cordilleri* et *Symphysurina* apparaissent dans la partie supérieure de la Zone à *Missisquoia*; l'extension de ces deux taxa est prolongée dans la zone A. Le sommet de la Zone à *Missisquoia* est arbitrairement fixé à la dernière apparition du genre éponyme. Dans la partie supérieure du membre basal silteux, les trilobites de la zone A comprennent *Geragnostus (Micragnostus) chiushuensis*, *Symphysurina*, les derniers représentants de *H.? cordilleri* et les premiers exemplaires de *Clelandia albertensis* et de *Jujuyaspis borealis*.

Les macrofossiles déterminables sont pratiquement absents des pélites vert-gris formant la majorité du membre du schiste d'aspect mastic. De minces lits de microgrès calcaire, dont certains sont formés de conglomérats, contiennent *G. (M.) chiushuensis*, *J. borealis*, *C. albertensis* et *Symphysurina*, tous apparaissant dès le membre basal silteux. La base de la zone B est définie par l'apparition de *Bellefontia*, représenté par *B. nonius*.

Le membre moyen, épais de 199 m, contient une faune variée de trilobites uniquement dans les 43 m supérieurs. Le sixième inférieur du membre est daté de la zone B par *Bellefontia* et *Parabellefontia*. Les limites de la zone D sont définies par l'extension de *Kainella billingsi*. Aucun trilobite n'est trouvé dans les dépôts intermédiaires et arbitrairement attribués à la zone C, unité mal définie dans l'Utah, sa région-type. La base et le sommet de la zone E sont fixées par la distribution de *Paenebeltella convexa*, espèce dont l'extension se poursuit, tout comme celle de l'abondant *Leiostegium (Evansaspis) ceratopygoides*, dans la partie la plus inférieure du membre supérieur massif. Dans la partie supérieure du membre moyen, *Gonioteloides monoceros*, *Hyperbolochilus*, *Pseudoclelandia fluxafissura* et *Tesselacauda flabella* sont les autres espèces caractéristiques de la zone E.

Les lits calcaires épais, souvent à thrombolithes, du membre supérieur massif, particulièrement dans les deux-tiers supérieurs, contiennent peu de trilobites. Seule, *Pseudoclelandia cornupsittaca*, espèce rare dans l'Utah, est caractéristique de la zone F. Au Défilé de Wilcox, les limites de cette dernière sont définies par le sommet et la base des zones sous- et sus-jacents; les Hystricurides ont été trouvés seulement dans les zones D et E, et dans la partie inférieure de la zone F.

La Formation d'Outram, épaisse de 266 m, a été déposée en milieu plus profond; en particulier, les roches incluent des pélites gris foncé et des calcaires gris et nodulaires. Les genres de trilobites comprennent plusieurs asaphacéens, de rares pliomérides et des téléphinides *Carolinites*. Ces derniers, très répandus, étaient probablement pélagiques. Les macrofossiles sont absents des 4,20 m inférieurs de la formation, arbitrairement attribués à la zone F. La zone G n'a pu être subdivisée comme elle l'est dans l'Utah; ses limites inférieure et supérieure coïncide avec celles de l'extension d'*Aulacoparia (Aulacoparia) sculpta*. Le kainellide *Menoparia elegans* et le ?lecanopygide *Benthamaspis obrepta*, connu dans l'Utah et dans le Montana, sont aussi présents dans la zone G. Les zones H et I (indifférenciées) correspondent à des couches ne contentant presque pas de macrofossiles. La base de la zone J coïncide avec l'apparition de *Lachnostoma latucelsum*, une espèce de l'Utah, étendue jusque près du sommet de la Formation

d'Outram. *Benthamaspis canadensis*, *B. diminutiva*, *Goniotelina brevis*, *Pliomeridius lacunatus*, *Presbynileus* (*Presbynileus*) *latifrons*, *Protopliomerops*? *radiatus*, *Pseudocybele nasuta* et *Ptyocephalus declevitus* sont aussi présents dans la zone J.

La plus grande partie de la Formation de Skoki consiste en des lits épais de dolomite avec des horizons subsidiaires de nodules siliceux et sombres. Les trilobites de deux minces lits de calcaire, dans les 6,40 m les plus inférieurs, contiennent des espèces trouvées plus haut dans la même formation d'Outram ainsi que *Cybelopsis speciosa*; ils indiquent la zone J.

INTRODUCTION

Wilcox Pass, the area from which most of the trilobites described were obtained, lies in the Main Ranges of the southern Canadian Rocky Mountains, 6 km north of the boundary between Banff and Jasper National Parks, Alberta (Fig. 1). The principal lithostratigraphic units, in ascending order Survey Peak Formation and Outram Formation, were founded by Aitken and Norford (1967) on sections at Mount Wilson, beside the North Saskatchewan River, 70 km northwest of Lake Louise; the overlying Skoki Formation was introduced by Walcott (1928, p. 217, 218) with the type section at Skoki Mountain, 70 km southeast of Mount Wilson. The nomenclature of these and adjacent formations in the region was reviewed by Norford (1969a). Steep slopes make detailed stratigraphic collecting difficult at the Mount Wilson section, and the present work on the more easily reached section at Wilcox Pass was begun, as part of GSC Project 690006, at the suggestion of Brian Norford, who accompanied me on my first visit to the area. Systematic collecting was carried out in the summers of 1972, 1973 and 1976, resulting in a preliminary report (Dean, 1978) that outlined the results. In the present paper, that report is used as the basis for the systematic descriptions of the trilobites obtained, but more detailed information on the stratigraphic distribution of the trilobites within each formation or member is given (Figs. 7-9) and the positions of relevant fossil localities are shown in Figures 2 to 6. Brachiopods collected by the writer are now being described by M.G. Bassett, Acritarchs were collected systematically from the Wilcox Pass section in 1981 by the writer and F. Martin, some of whose preliminary results have already been published (Martin, 1982; Dean and Martin, 1982).

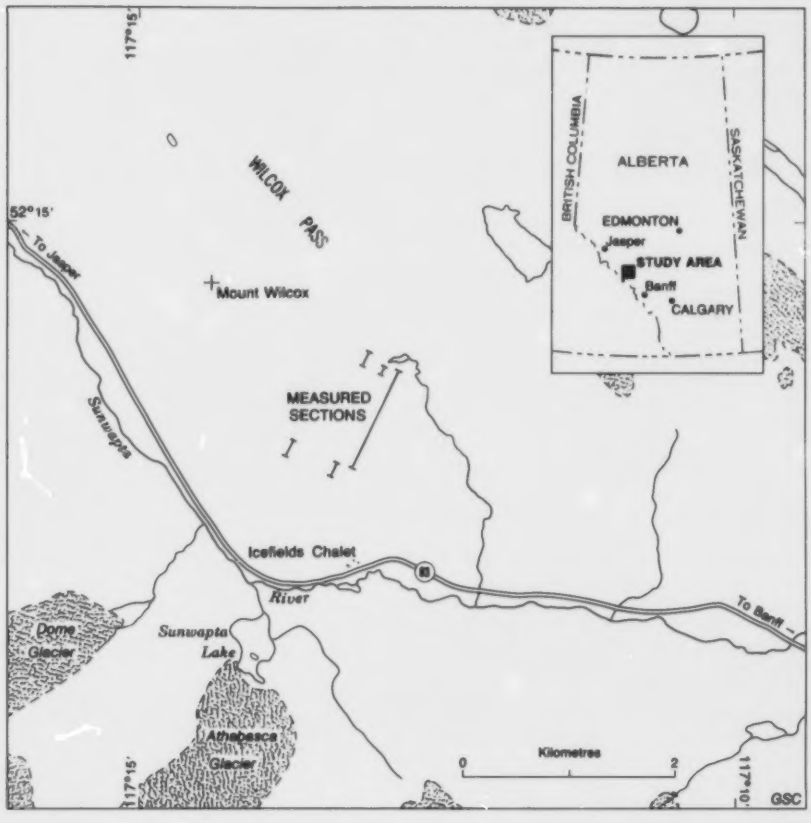


Figure 1. *Outline maps showing location of Wilcox Pass and other places in Western Canada cited in text.*

Acknowledgments

Collecting was carried out thanks to permits granted by the Director of the Western Region, Parks Canada. I am much indebted to R.J. Ross Jr., who read the manuscript and made suggestions for its improvement. Type material from the Smithsonian Institution, Washington, D.C. and the Museum of Comparative Zoology, Harvard was loaned by F. Collier and by S.J. Gould. During the early sampling, assistance in transporting specimens was given by J. Dean and T. Dean.

REVIEW OF LITHOSTRATIGRAPHIC TERMINOLOGY

The rock units of latest Cambrian and earliest Ordovician age in the area were established by Aitken and Norford (1967) mainly on the basis of studies of the cliff section on the south face of Mount Wilson, about 35 km southeast of Wilcox Pass (Fig. 1). They were reviewed by Norford (1969a) and Aitken, Fritz and Norford (1972), and their development of Wilcox Pass was summarized by Dean (1978). In chronostratigraphic terms the strata range from the Trempealeau Series (in part) to what has traditionally been known as the Canadian Series, a name much used in the past but considered inappropriate by Ross et al. (1982), who replaced it by the more precisely defined term Ibex Series. The base of the Survey Peak Formation at Wilcox Pass is slightly younger than at Mount Wilson (Dean, 1978, p. 4; Westrop, Landing and Ludvigsen, 1981, p. 45), and other lithostratigraphic boundaries in the region may also prove to be diachronous.

The Survey Peak Formation, some 357 m thick in the study area, is divisible into four informal members, which are successively: basal silty member, 42 m; putty shale member, 38 m; middle member, 199 m; and upper massive member, 78.5 m.

The basal silty member consists of calcareous and dolomitic siltstone, both thin and thick bedded, with shale interbeds; impersistent beds of flat pebble conglomerate and thrombolitic limestone (Aitken, 1967) are common, particularly in the lower part of the member. Fossils are confined to thin, lenticular horizons, sometimes of calcarenite; most are disarticulated trilobites, with occasional brachiopods. The proportion of shale increases higher in the member, which eventually grades into the putty shale member, whose pale, green-grey beds form a regressively weathering but distinctively coloured unit that is visible even from a distance. Thin beds of brown weathering, occasionally fossiliferous, siltstone and flat pebble

conglomerate occur; the predominantly shale lithology yielded no macrofossils and the virtual absence of graptolites was noteworthy.

The middle member, though 199 m thick in the study area, is less clearly definable than either the putty shale or upper massive members, and was originally established on the basis of its intermediate stratigraphic position. Grey, silty shale is a notable component throughout, although it is subsidiary to limestone and dolomite, which are common; impersistent beds of conglomerate occur sporadically. Fossiliferous levels (Fig. 3) are few and far between, except in the topmost fifth, where most of the trilobites and a few brachiopods were found. The remainder of the succession proved to be only sparsely fossiliferous, with a few disarticulated trilobite fragments in calcareous siltstone or impersistent calcarenite. Fragmentary hystricurids were found uncommonly throughout both the upper two-thirds (approximately) of the middle member and the lower half of the upper massive member.

The base of the upper massive member was drawn arbitrarily by Aitken and Norford (1967, p. 169) "where thick thrombolitic beds become prominent upwards; in all sections observed, the content of shale decreases markedly at the same level". At Wilcox Pass these thick, resistant beds form a conspicuous, topographically lower feature on the north side of the small hill, topped by a cairn, that dominates the southeast end of Wilcox Pass. This hill is formed of limestone belonging to the upper part of the middle member.

Up to this point the conditions of marine deposition (Aitken and Norford, 1967, p. 167-169) were not only very shallow but occasionally emergent. Slightly deeper, but poorly aerated water was said to be indicated by the 266 m of strata of the Outram Formation, though a depth of only 1 to 4 fathoms (= 1.8 to 7.3 m) was postulated, the area of deposition lying between the middle carbonate and outer-detrital belts (for terminology, see Palmer, 1969, p. 140). Aitken and Norford (pers. comm., 1986) now consider that "in the light of advances in sedimentology over the past twenty years, the Outram Formation may be a slope deposit laid down in water much deeper than we thought in 1967. Restudy of the coarse-grained and oncolitic limestone beds might establish that they are resedimented ('allodapic')". Such an interpretation is more in keeping with the palaeontological evidence (see also Dean, 1978). The rocks are generally darker than those of the Survey Peak Formation and consist of several lithotypes, the most conspicuous of which is limestone made up of numerous small nodules that are embedded in, and frequently weathered from, a grey shale matrix. No macrofossils were found in the small nodules, though well preserved trilobites proved to be common locally in some beds of larger nodules. Resistant, thick beds of limestone and calcareous siltstone are common and often give rise to strike-oriented features on the hill slope that descends to the small lake at the southeastern end of Wilcox Pass. Coincident with the increase in depth of deposition of the strata there is a marked increase in abundance and diversity of trilobites. This is particularly so for the asaphids (of which at least seven genera are present), but there are also forms with large eyes, such as the kainellid *Menoparia* and the geographically widespread, probably pelagic, telephinid *Carolinites*. A feature of the trilobites

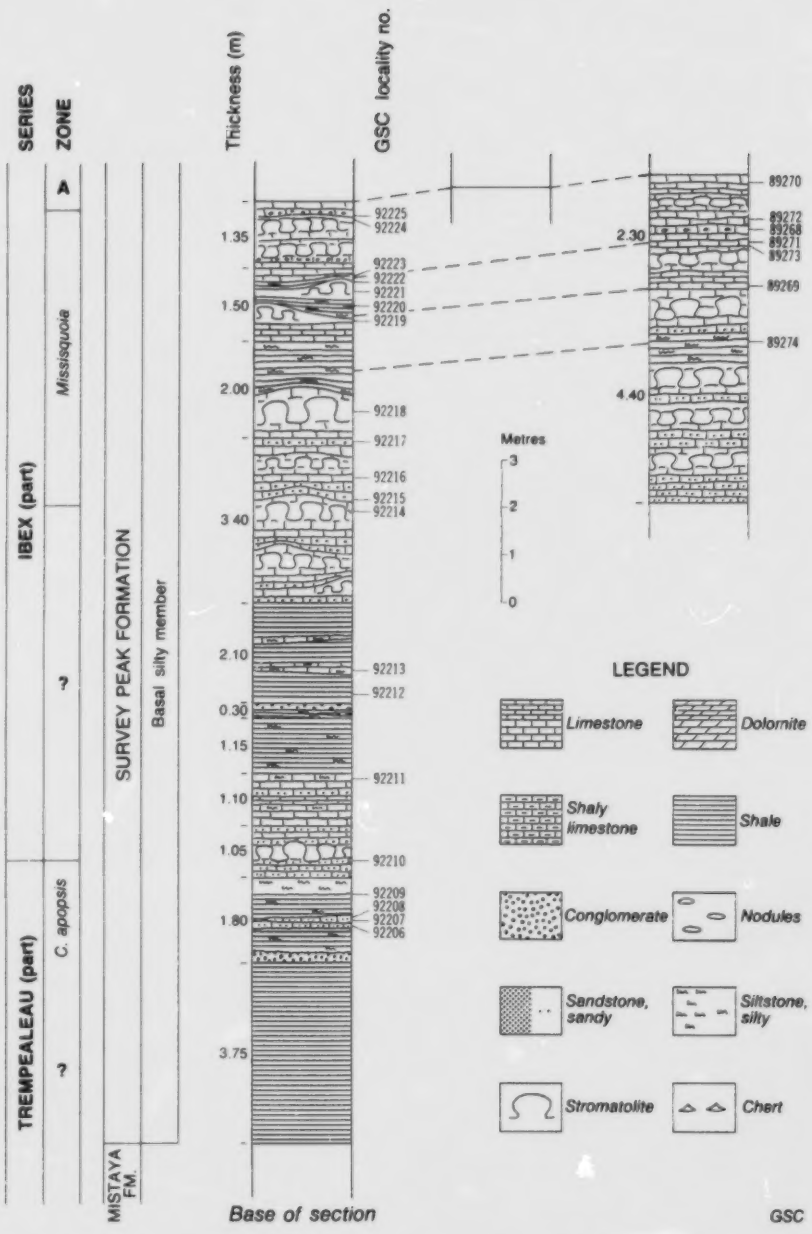
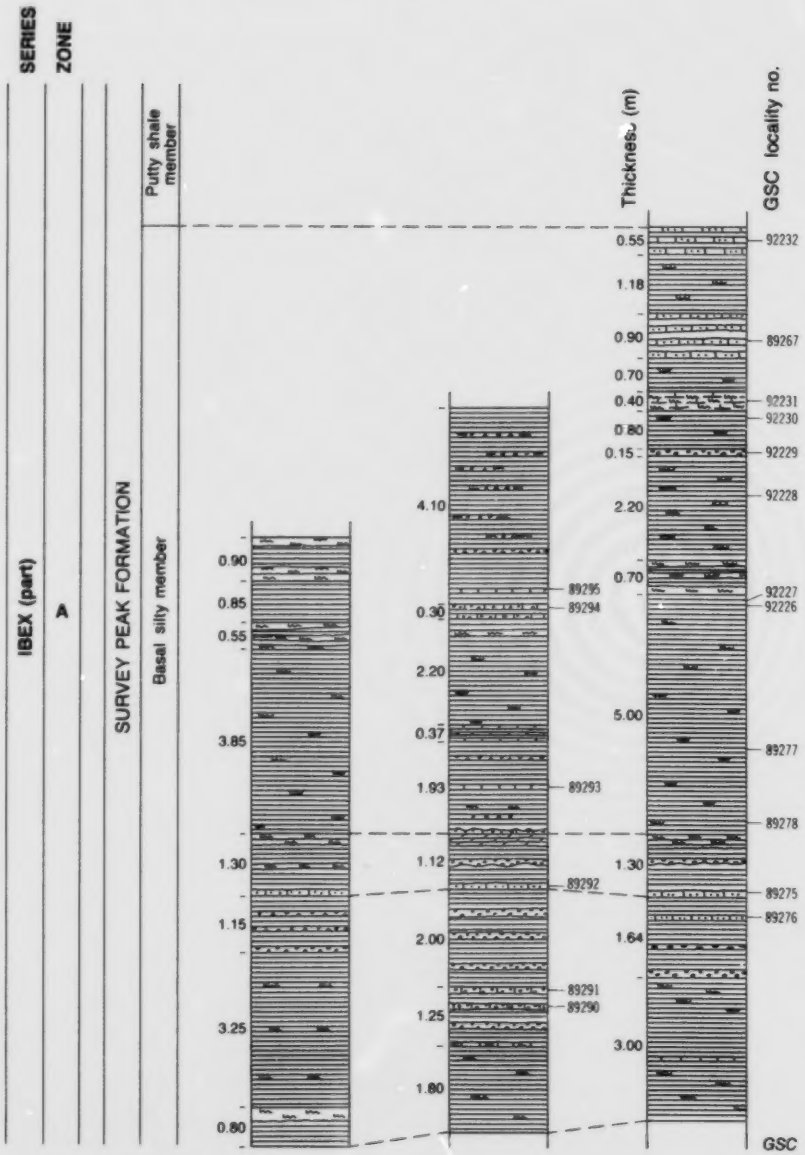


Figure 2. *Measured sections showing fossil localities in the basal silty member of the Survey Peak Formation. The bases of the columns on the right hand page overly the top of those on the left hand page.*



found in the upper half of the Outram is the relative abundance of pliomerids, a group almost unrepresented in the Survey Peak Formation. No example of an articulated trilobite exoskeleton was found in any of the formations sampled at Wilcox Pass.

The Skoki Formation, only the basal 6.4 m of which are relevant to the present account, is made up mostly of dolomitic strata, often thick bedded, with minor, thin beds of limestone in the lowest part, and notable developments of chert throughout. Macrofossils, collected at only two levels in the lowest 6.4 m, proved to be surprisingly varied; eight trilobite genera were found, all of which are known from the uppermost Outram Formation (Fig. 9). The boundary between the two formations is gradational (Aitken and Norford, 1967, p. 175; Dean, 1978, p. 9), involving alternations of the two typical lithotypes, and the base of the Skoki is drawn arbitrarily at the section near the western end of the small lake noted earlier, in the account of the Outram Formation.

BIOSTRATIGRAPHIC SUCCESSION

As a consequence of the mostly shallow marine environments represented by the Survey Peak and Outram formations, the macrofossils are largely of benthic type. There is a preponderance of trilobites that often exhibit close affinities with corresponding faunas that extend, at both generic and specific level, for considerable distances over and around the North American craton and related parts of Laurentia. Brachiopods occur uncommonly at a few levels in the basal silty and middle members of the Survey Peak Formation and parts of the Outram Formation and basal Skoki Formation. Molluscs are rare and graptolites are almost non-existent, none being found during the present collecting to supplement the meagre records in Aitken and Norford (1967). Faunal affinities with Utah and Nevada are sufficiently close for a correlation to be attempted with the largely trilobite-based zonation established there by Ross (1949, 1951a) for rocks of Early Ordovician age that make up the Garden City Formation and Swan Peak Formation. In its original form, an index letter, from A to M, was used for each zone and lists of characteristic species were given (Ross, 1951a, p. 27-29). Later, Hintze (1953, p. 5-23) added zones N and O, while zones from B upward were assigned zonal names based on one or more index fossils, mostly trilobites but in two cases brachiopods and in one the coral *Eofletcheria*. Hintze's scheme has proved to be less satisfactory at Wilcox Pass due to the paucity of some of the index fossils, particularly pliomerid trilobites, and in this paper, Ross's original sequence of lettered zones is preferred, though its use is not without problems. Some of the genera and species of zonal value occur also in the Mount Robson and Radium Hot Springs areas of British Columbia, but the detailed sequence there has not yet been established. In the following paragraphs the names of authors of species are omitted, but they may be found in the systematic descriptions.

Highest Trempealeau Series and lowest Ibex Series

The Cambrian-Ordovician boundary in North America was conventionally drawn between the *Saukia* Zone, highest Trempealeau Series, and the *Symphysurina* Zone, lowest Canadian Series. Ross and others (1982, p. 7) proposed replacing the latter by Ibexian Series, and in this paper the two series names are used in the form of Trempealeau and Ibex, the suffix -ian being reserved for names of stages in the chronostratigraphic hierarchy.

Trempealeau Series

Saukia Zone; Corbinia apopsis Subzone

The *Corbinia apopsis* Subzone was introduced in central Texas by Winston and Nicholls (1967, p. 69) as the youngest of three subzones constituting the *Saukia* Zone. The trilobite fauna consisted of the index species and five others (including *Apatokephaloides clivosus*) restricted to the subzone, plus a further five with longer vertical ranges. The term *Corbinia apopsis* Subzone was used in a similar sense by Stitt (1971, 1977) and by Taylor (1977), though as the youngest of four subzones in the *Saukia* Zone. More recently Ludvigsen and Westrop (1985) modified the name of the eponymous trilobite to *Eurekia apopsis* and employed the *Saukia* Zone within a new Sunwaptan Stage, based on the strata in the area south of Wilcox Pass (see also Westrop, 1986). The introduction of Sunwaptan and three underlying stages by Ludvigsen and Westrop has not been generally accepted (see Robson et al., 1985), and Trempealeau is retained here. Taylor has revised *Eurekia* (Taylor, 1978), and informs me (pers. comm.) that he considers it to be distinct from *Corbinia*, the type species of which, *C. horatio*, was first described from Alberta and occurs at Wilcox Pass. For present purposes the usage of *Corbinia apopsis* Subzone is continued.

At Wilcox Pass the lowest 4.5 m (approximately) of the basal silty member consist of poorly exposed silty shale that yielded no macrofossils; in succeeding strata, the thickness of at least 1.4 m for the *C. apopsis* Subzone is based on the recorded range of *Corbinia horatio*. Of the three other trilobite species recorded, *Apatokephaloides clivosus* was found at only two localities, 4.5 m and 4.7 m above the base of the member, while *Apoplanias rejectus* and *Plethometopus obtusus* extended still higher. The two latter are the only trilobites found within 7.6 m of strata, whose zonal position is uncertain, between the highest record of *C. horatio* and the lowest record of *?Missisquoia*.

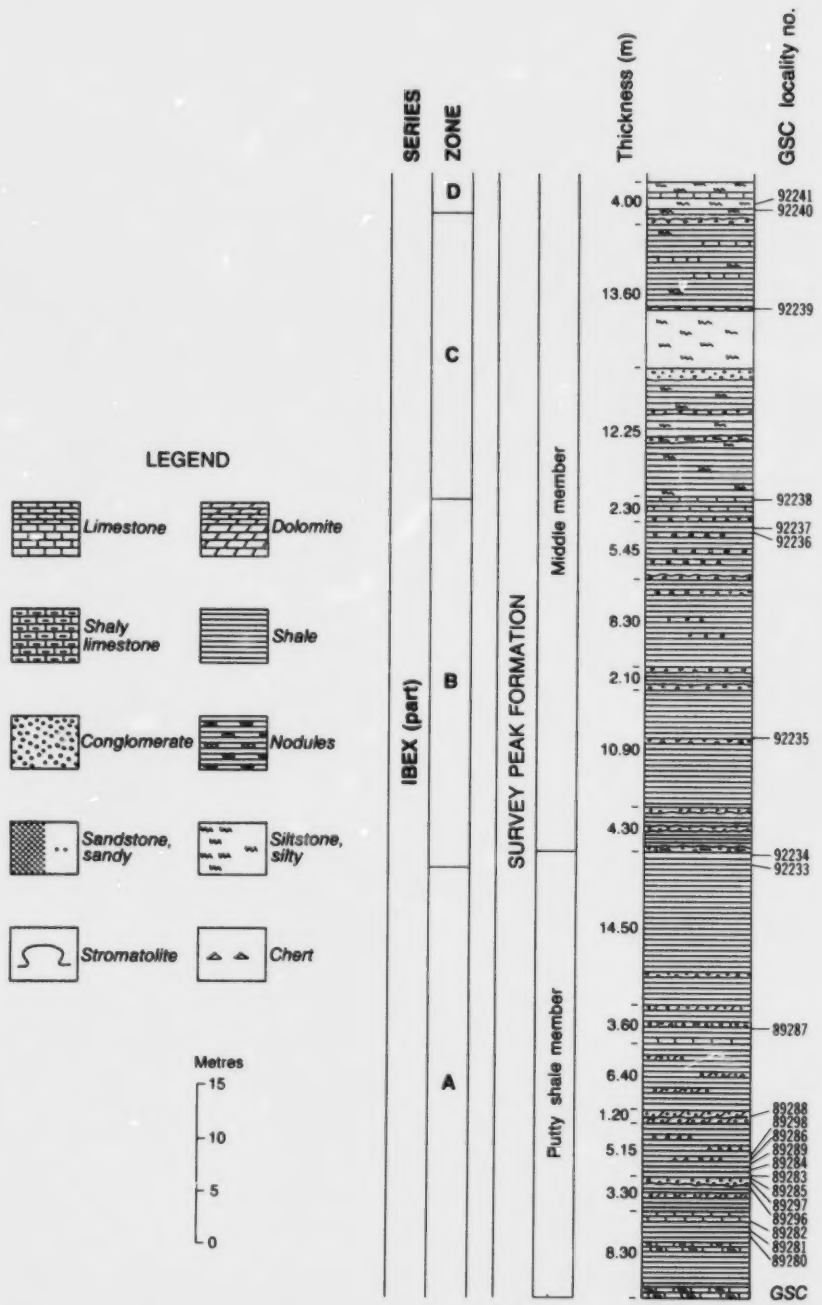


Figure 3. *Part of the measured section of the Survey Peak Formation. (Figures 3-6 show successive parts of the measured section of the Survey Peak, Outram and Skoki formations).*

Ibex Series

Zone A and the Missisquoia Zone (Fig. 7)

The earlier usage of a *Symphysurina* Zone to denote the lowest part of the series was followed by the introduction of a *Missisquoia* Zone, succeeded by a *Symphysurina* Zone, by Winston and Nicholls (1967, p. 70, 72). *Missisquoia* Zone, undivided, was employed by Taylor and Cook (1976, p. 201) for both shelf and slope biofacies in Nevada, and also by Taylor (1977, p. 400), succeeded by the *Symphysurina* Zone and zones C to J. Stitt (1971, 1977, 1983) subdivided the *Missisquoia* Zone into successive *M. depressa* and *M. typicalis* subzones, *Missisquoia* may prove eventually to be a junior synonym (see discussion by Jell and Stait, 1985, p. 41-43), but is retained pending a revision of it and related genera.

Ross (1949, p. 48) recorded only three trilobite genera, *Bellefontia*?, *Hystricurus* and *Symphysurina*, when introducing Zone A and noted apprehensively that "This zone is possibly not a valid one"; nevertheless it has survived to be included in the latest Ordovician correlation tables for the U.S.A. (Ross et al., 1982). It was listed as the *Symphysurina-Euloma* Zone by Aitken and Norford (1967, p. 180), a term updated to *Symphysurina-Highgatella* Zone by Dean (1978, p. 7) but not used here.

Missisquoia, including *M. typicalis*, proved to be uncommon at Wilcox Pass, found only (including records questionable at species level) through 5.7 m of the basal silty member. No subdivision of the *Missisquoia* Zone was possible. Between the uppermost record of *Missisquoia* and the lowest of *Bellefontia* (indicative of Zone B) are 60 m of strata made up of the uppermost 18.8 m of the basal silty member and the lowest 41.2 m of the putty shale member. Trilobites in this interval include: *Symphysurina* and *Highgatella*?, both found also in the *Missisquoia* Zone; *Jujuyaspis borealis*; *Clelandia*, mostly *C. albertensis*; and *Geragnostus chiushuensis*, apparently of no zonal value. The *Symphysurina* Zone would be inappropriate for these strata, which are therefore referred to Zone A. *Jujuyaspis* is widespread, described from the lower Tremadoc of Norway (Henningsmoen, 1957, p. 261) and Argentina (Harrington and Leanza, 1957, p. 97); *Clelandia* has been found in a conglomerate in the Girvan district, Scotland (Rushton and Tripp, 1979).

In the western District of Mackenzie, northwestern Canada, strata of the Rabbitkettle Formation may be correlated broadly with the basal silty and putty shale members of the Survey Peak Formation. However, they consist of dark, argillaceous mudstone containing trilobites which are dominated by olenids, sufficiently distinct to necessitate the introduction of a different zonation (Ludvigsen, 1982, p. 7-17). That zonation included a *Yukonaspis* Zone, uppermost Trempealeau, followed by a *Parabolinella* Zone and *Symphysurina* Zone in the Ibex.

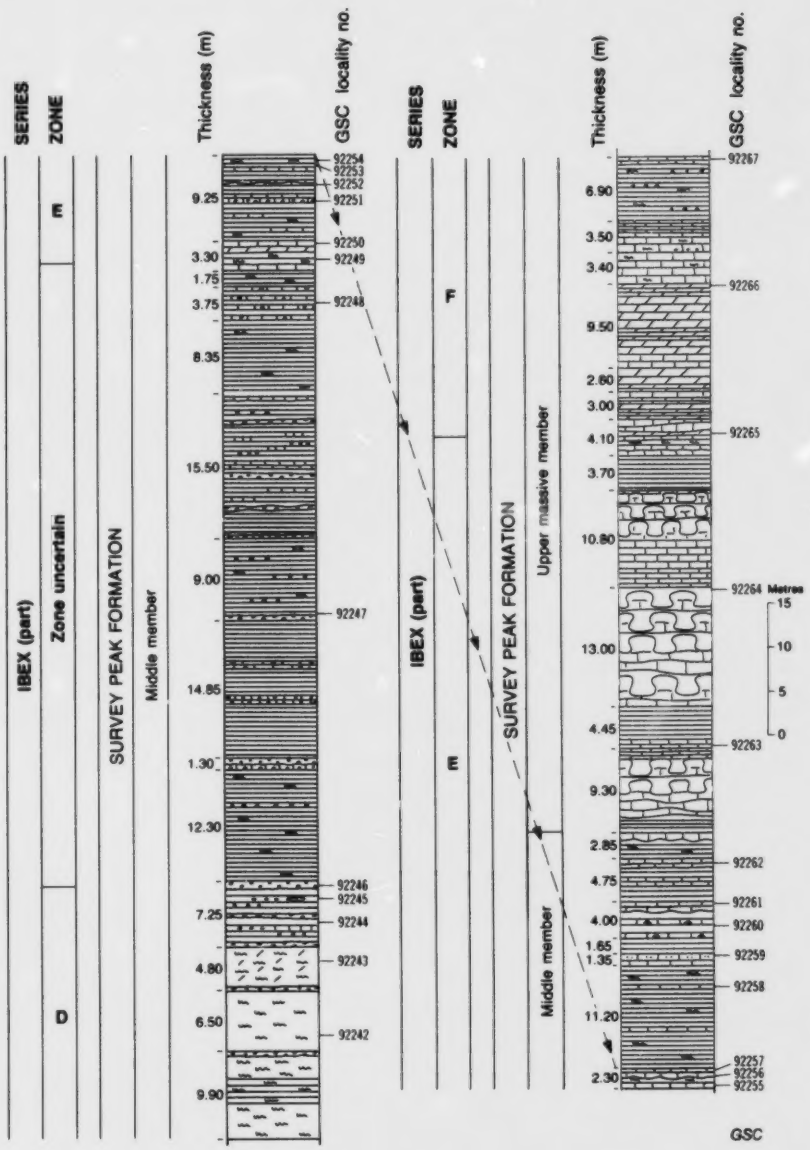


Figure 4. *Part of the measured section of the Survey Peak Formation. The top of the left hand column is succeeded by the base of the right hand column, as indicated by the arrows. (See Figure 3 for legend).*

The *Elkanaspis corrugata* Fauna, in the uppermost part of the *Yukonaspis* Zone, has only *Plethometopus obtusus* in common with Wilcox Pass, where the species occurs in the *C. apopsis* Subzone and overlying beds of uncertain age. The *Parabolinella* Zone was divided into three: a. *Missisquoia mackenziensis* Fauna; b. *M. depressa* Subzone; and c. *Apoplanias rejectus* Fauna. The only trilobite species in common with Wilcox Pass are: *P. obtusus* in a and b; and *A. rejectus* in c, from which only two species were recorded. The *Symphysurina* Zone likewise contained only two species, *A. rejectus* and *Symphysurina* cf. *S. brevispicata*; the former was found no higher than the *Missisquoia* Zone at Wilcox Pass, and the latter (a species placed here in synonymy with *S. walcotti*) in Zone A.

Zone B (Figs. 7, 8)

Trilobites listed by Ross (1949, p. 481) included *Bellefontia*, *Clelandia*, *Hystricurus*, *Symphysurina*, *Xenostegium*, and a small *Remopleurides*-like genus (later *Remopleuridiella*). To these Ross (1951a, p. 29) later added *Parahystricurus*. The *Symphysurina* Zone of Hintze (1953, p. 5, 7) was equated by him with Ross's Zone B, but appears to include also at least part of Zone A (Norford, 1969, p. 2; Dean, 1978, p. 6). The unit was referred to as the *Bellefontia-Xenostegium* Zone by Aitken and Norford (1967, p. 180) and by Stitt (1983, p. 8), who divided it into three subzones.

At Wilcox Pass the meagre fauna includes only *Bellefontia nonius*, the vertical range of which forms the basis for the zonal limits, and *Parabellefontia concinna*, found high in Zone B in Utah (Hintze, 1953, p. 195).

The vertical distribution of trilobites in the basal silty member and putty shale member at the Mount Wilson section, summarized by Derby et al. (1972), differs in minor detail from that described herein (Figs. 7-9). The fauna of the *C. apopsis* Subzone at both sections includes *Apatokephaloides clivosus* and *Plethometopus* (though different species). *Apoplanias rejectus* was found at Wilcox Pass in the *C. apopsis* Subzone and *Missisquoia* Zone. At Mount Wilson it was reported only in the lowest *Missisquoia* Zone, but as the base of the latter unit was drawn by Derby et al. at a level lower than the lowest record of *Missisquoia*, the distribution of *A. rejectus* there may not differ significantly from that at Wilcox Pass.

Strata above the *Missisquoia* Zone at Mount Wilson were assigned to the *Symphysurina* Zone, equated by Derby et al. (1972, p. 509) with Zone A. The base was defined by the appearance of *Symphysurina*, a genus not recorded by them from the *Missisquoia* Zone. Elsewhere, however, the two eponymous genera occur in association, not only at Wilcox Pass but also at Highgate Falls, Vermont, including the type locality of *Missisquoia typicalis*. *Highgatella? cordilleri* was recorded only from the *Symphysurina* Zone at Mount Wilson, whereas at Wilcox Pass it occurs also in the *Missisquoia* Zone. These apparent faunal differences between Mount Wilson and Wilcox Pass may be due to collection failure, but might also reflect facies changes between the two sections.

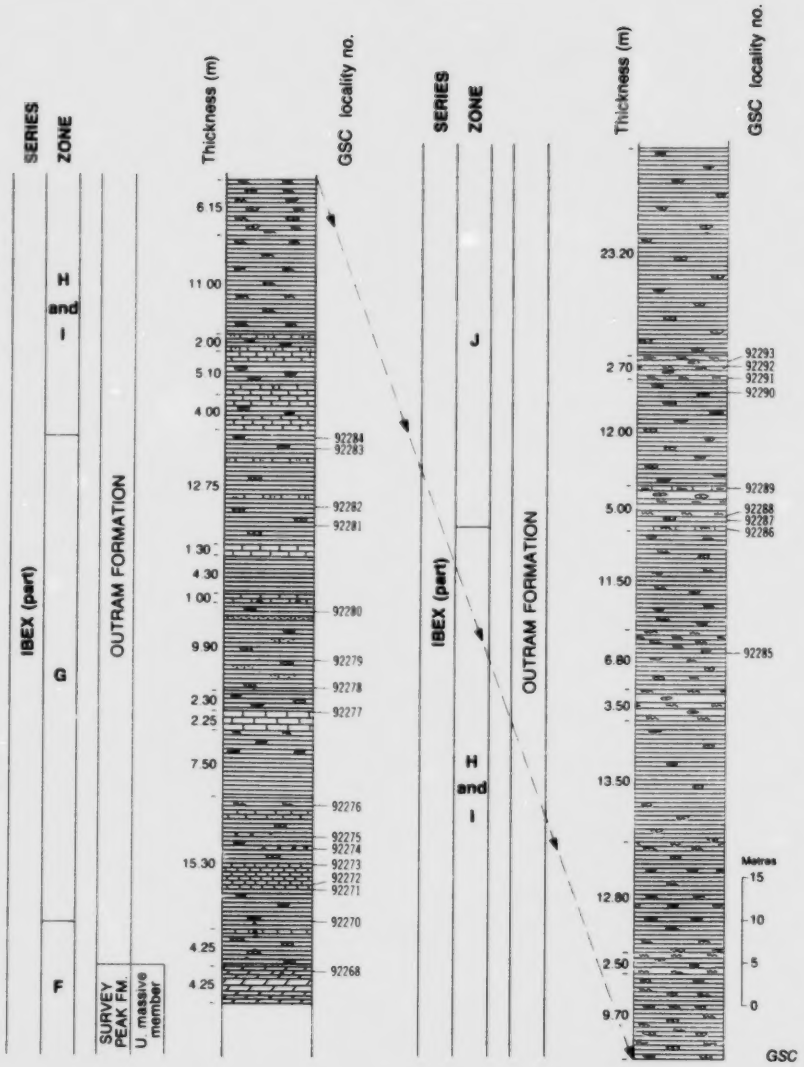


Figure 5. *Part of the measured section of the Outram Formation. The top of the left hand column is succeeded by the base of the right hand column, as indicated by the arrows. (See Figure 3 for legend).*

Zone C (Fig. 8)

Ross's (1949, p. 481) original faunal list included only one trilobite, *Symphysurina* sp. (close to *S. spicata* Walcott), and the brachiopods *Nanorthis*? sp. and *Syntrophina*? sp. Genera added later (Ross, 1951a, p. 29, 73) were *Hystricurus*? and *Pachycranium*?. Zone C was subsequently termed the *Paraplethopeltis* Zone by Hintze (1953, p. 5, 8), and listed as "*Paraplethopeltis*" Zone by Aitken and Norford (1967, p. 180). Although Hintze used *Paraplethopeltis* Bridge and Cloud, 1947, founded on an incompletely known type species from Texas, as zonal index, he referred material from Utah only questionably to the genus; the only other trilobite recorded by Hintze (1953, p. 165) was *Hystricurus genalatus* Ross (1951, p. 42), a species recorded solely from Zone B by Ross but from zones B and C by Hintze. Both *Hystricurus*? sp. 1 and *Pachycranium*? of Ross (1951a, p. 56, 73) were said by Hintze (1953, p. 202) to be congeneric with his own material of *Paraplethopeltis*? from Utah. Thus, even in its type area, Zone C is poorly defined, and at Wilcox Pass the problem is compounded by the presence within the corresponding part of the middle member of an interval, from 33 m to 60.6 m above the base of the member, from which no macrofossils were obtained. For present purposes it was found practical to draw the base and top, respectively, of Zone C at levels immediately above the highest record of *Bellefontia* and immediately below the lowest record of *Kainella*; using these criteria the thickness of Zone C is 27.6 m.

Zone D (Fig. 8)

The only fossils recorded by Ross (1949, p. 481; 1951a, p. 29) were *Apheoorthis* cf. *A. meeki* and *Leiostegium manitouense*. Subsequently Hintze (1953, p. 5, 9) named the unit *Leiostegium-Kainella* Zone and listed *L. manitouense*, *Apatokephalus finalis*, *Hystricurus* sp., *Kainella* sp. and *Pseudoclelandia* sp. He did not describe *Apatokephalus* or *Kainella*, and neither was recorded from the Garden City Formation by Ross. At Wilcox Pass both genera were found together at one level (GSC loc. 92241), 61.2 m above the base of the middle member of the Survey Peak Formation. *Kainella* was found through 82.9 m of the member, a figure interpreted here as the thickness of Zone D. The genus, though widespread, was probably subject to environmental

control, possibly preferring deeper water. All the specimens from Wilcox Pass are small and occur in shallow marine siltstone. Elsewhere, *Kainella* is recorded from boulders in the Lévis Conglomerate of Quebec (Rasetti, 1943, p. 101), from the subsurface of Montana (Ross, 1957, p. 500; Lochman, 1965, p. 480), and from the Tremadoc of South America (Harrington, 1938; Harrington and Kay, 1951; Harrington and Leanza, 1957).

A particular feature of the Utah faunas described by Ross and by Hintze is the number of hystricurids, some of zonal value, in rocks of Zones A to F. At Wilcox Pass hystricurids were confined to the middle and upper massive members of the Survey Peak Formation, in which fragmentary remains were found from Zones D to F.

The fauna of Zone D is not the same as the *Kainella-Evansaspis* fauna of Kobayashi (1955, p. 366), whose list from part of the McKay Group in British Columbia included, in addition to *Kainella*, other trilobites interpreted here as indicative of Zones D and E; the latter include *Goniotelоides monoceros*, *Paenebeltella convexa* and *Tesselacauda flabella*.

Zone E (Fig. 8)

Ross (1949, p. 481) based the zone on the occurrence of eleven species, including three of *Hystricurus*, one "very close to *Beltella*", and one (later *Tesselacauda*) "intermediate between *Pilekia* and *Protopliomerops*". Named species of trilobites later described by Ross (1951a) included: *Hystricurus robustus*, *Parahystricurus carinatus*, *Amblycranium variabile*, *A.? populus*, *Paenebeltella vultulata*, *Amechilus palaora*, *Pseudoclelandia lenisora* and *Tesselacauda depressa*. Of these, *Tesselacauda* was chosen as the zonal index by Hintze (1953, p. 10) who recorded from the Pogonip Group: *T.* aff. *depressa*, *Amblycranium variabile*, *Hillyardina* sp., *Hystricurus robustus*, *H.* cf. *oculilunatus*, *Leiostegium formosa*, *Pseudoclelandia* aff. *fluxafissura* and *Pilekia? trio*. Subsequently Terrell (1973, p. 89) described *T. depressa* as common in the lower Fillmore Formation of western Utah and extended its vertical range downward into Zone D. The genus proved to be an inappropriate zonal index at Wilcox Pass, where it was found at only two levels, 169 m and 190.3 m above the base of the middle member. The species there is *T. flabella*, described first (Kobayashi, 1955) from the McKay Group near Radium Hot Springs, almost 200 km south-southeast of Wilcox Pass (Fig. 1), and not yet reported elsewhere. *Tesselacauda* sp. was listed from a similar level at Mount Wilson (Aitken and Norford, 1967, p. 181, 194).

Strata assigned here to Zone E lie above 36 m of the middle member that succeed the highest record of *Kainella* and in which no macrofossils were found. The base and top of Zone E are drawn arbitrarily at the first and last occurrences, respectively, of *Paenebeltella*, a genus recorded in Utah only from Zone E by Ross, not at all by Hintze, and from Zones D and E by Terrell (1973, p. 79). *Paenebeltella* is represented at Wilcox Pass by *P. convexa* in the highest 40 m of the middle member and the lowest 26.5 m of the upper massive member. *Paenebeltella convexa*, recorded from an apparently similar horizon at Mount Wilson (Aitken and Norford, 1967 p. 181, 194), was first described from the McKay Group of British Columbia. Further evidence of affinities with Utah is provided by *Hillyardina* and *Hyperbolochilus*.

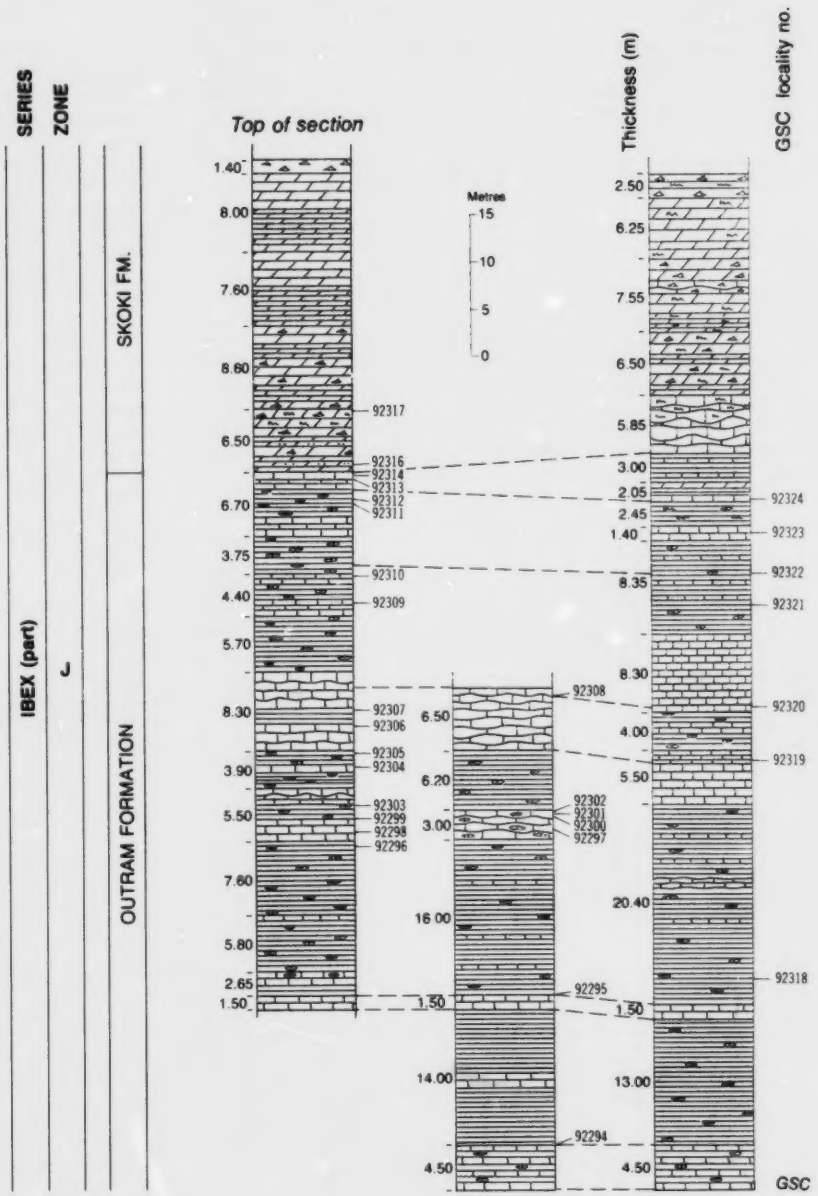


Figure 6. *Part of the measured section of the Outram and lowest part of the Skoki Formation. The top of the left hand column is succeeded by the base of the right hand column, as indicated by the arrows. (See Figure 3 for legend).*

One of the most common and stratigraphically useful trilobites in the lower half of Zone E at Wilcox Pass is *Leiostegium* (*Evansaspis*) *ceratopygoides*, a senior subjective synonym of both *L. formosa*, from Utah, and *L.* (*E.*) *glabrum*, type species of *Evansaspis*, from the McKay Group of British Columbia (Kobayashi, 1955). Even fragments of the pygidium, with its characteristic paired spines, can be easily recognized. The species was found between 166.8 m and 194.7 m above the base of the middle member.

Gonioteloides appears to have some potential for correlation of part of Zone E in western North America. *Gonioteloides monoceros*, the type species, described first from the McKay Group of British Columbia, was found at a single level (GSC loc. 92256) in the lower part of Zone E, 171.3 m above the base of the middle member at Wilcox Pass, and was recorded from a similar, if not identical, horizon at Mount Wilson (Aitken and Norford, 1967, p. 181, 194). Kobayashi's (1955, p. 365) record of *G. monoceros* from both Zone E and his "*Symphysurina* Fauna" (= Zone B) is considered here to be an error. *Gonioteloides* cf. *G. monoceros* was described from Zone E of Colorado by Berg and Ross (1959).

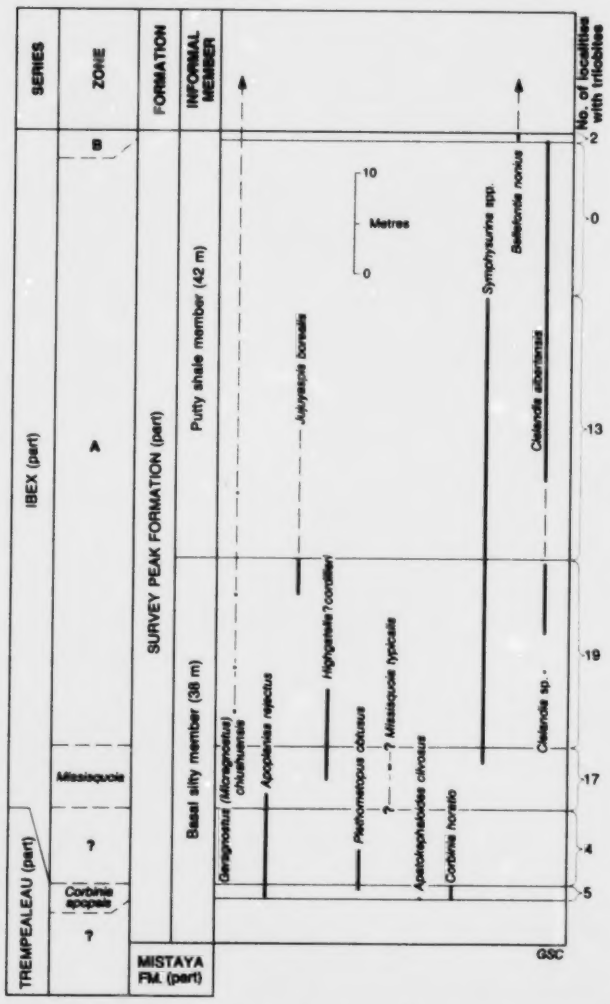


Figure 7. *Chart showing vertical range and age of trilobites in basal silty member and putty shale member of the Survey Peak Formation at Wilcox Pass.*

Zone F (Fig. 8)

In his first account, Ross (1949, p. 481) reported the occurrence of twenty-three trilobite species in the zone, but alluded only to four species of *Hystricurus* and one of *Protopliomerops*. Among the numerous trilobites described later (Ross, 1951a, p. 28-29) are: *Hystricurus* spp. (including *H. oculilunatus*), *Pseudohystricurus*, *Amblycranium*, *Hillyardina*, *Pachycranium*, *Hyperbolochilus*, *Pyraustocranium*, *Goniophrys*, *Hypothetica*, *Pseudoclelandia cornupsittaca* and *Protopliomerops superciliosus*. The last-named, chosen as the zonal index by Hintze (1953, p. 5, 11), was later made the type species of *Rossaspis* (Harrington, 1957, p. 812), a genus reported also from Argentina (Harrington in Moore, 1959, p. O444).

In the absence of positive evidence, the base and top of the zone at Wilcox Pass are drawn, respectively, immediately above the highest occurrence of *Paenebeltella convexa* and below the lowest occurrence of *A.* (*Aulacoparia*) *sculpta*. The remainder of the fauna includes only *Apatokephalus*? sp., *L.* (*Leiostegium*) *valmyense*, *Pseudoclelandia cornupsittaca* (Zone F in Utah) and fragmentary hystricurids.

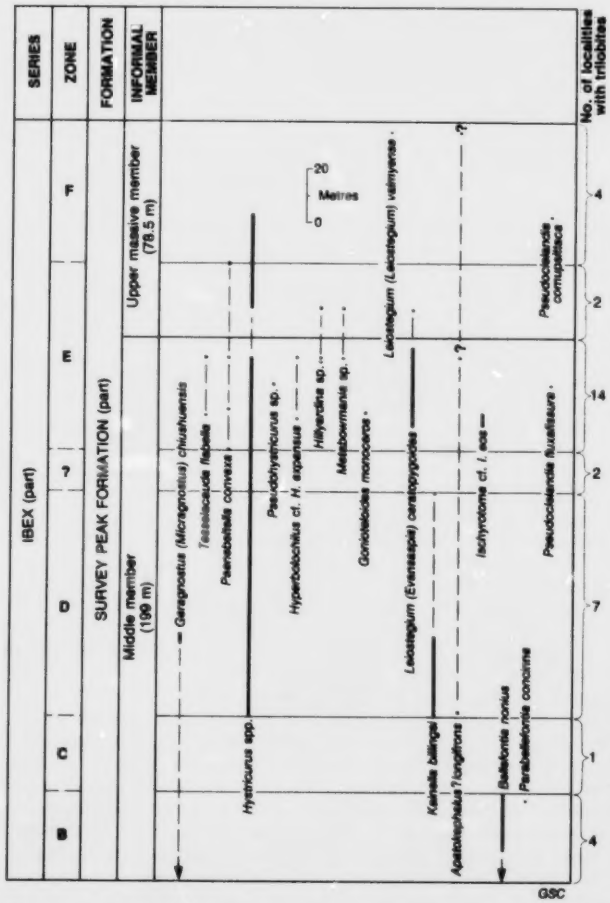


Figure 8. *Chart showing vertical range and age of trilobites in middle member and upper massive member of the Survey Peak Formation at Wilcox Pass.*

Zone G (Fig. 9)

This was described by Ross (1949, p. 480) as one of the most complex of his zones, "based on the occurrence of an *Apatokephalus*-like genus" (later *Menoparia*) and subdivided into successive subzones G(1) and G(2). Subsequently, the limits of the zone were said to coincide with the vertical range of *Menoparia genalunata* and *Psalikilus typicum* by Ross (1951a, p. 27); G(1) and G(2) were characterized by, respectively, *Protopliomerops celsaorus* and *P. contractus*. These subzones were later termed zones by Hintze (1953, p. 5, 11-14), and the index trilobites were subsequently assigned to *Hintzeia* and *Protopliomerella*, respectively, by Harrington (1957, p. 811). Other trilobites recorded by Ross (1951a, p. 28) are as follows: G(1), *Hintzeia celsaora*, *Asaphellus*? *eudocia* (now assigned to *Aulacoparia*?) and *"Xenostegium" taurus* (not that species, but a cranidium of *Aulacoparia* sp.); G(2), *Protopliomerella contracta*, *Peltabellia* (then *Jeffersonia*), *Scinocephalus solitecti*, *Macropyge gladiator* (including a cranidium now placed in *Aulacoparia*), and *Licnocephala bicornuta*.

At Wilcox Pass the lowest 4.2 m of the Outram Formation yielded no macrofossils, but the succeeding 54.8 m represent the vertical range of *A. (Aulacoparia) sculpta*, taken arbitrarily as the index fossil for Zone G (undivided). *Menoparia*, represented by *M. elegans*, was found at only three levels within a thickness of 16.5 m approximately in the middle of the zone, but its presence emphasises the close relationship with the Utah faunas. In the upper part of Zone G, *Benthamaspis* (previously *Oculomagnus*) *obrepta*, a rare species, was based on material from G(1) of Utah and is found in the subsurface rocks of the Williston Basin, Montana (Lochman, 1966, p. 541). Zone G at Wilcox Pass marks the appearance there of *Carolinites*, determined as *C.* aff. *C. tasmaniensis*. One specimen of *Peltabellia* sp. in the topmost part of Zone G is the only record of a genus founded on a species from Zone G(2) of Utah.

Zone H (Fig. 9)

Ross (1949, p. 480) reported only one trilobite, "*Xenostegium*"? cf. *goniocerum*, together with *Didymograptus* cf. *nitidus* and two species of *Dictyonema*. The trilobite was subsequently described (Ross, 1951a, p. 104) as *Trigonocerca typica*, a species employed as index for the zone by Hintze (1953, p. 5, 15, 16), who listed numerous trilobites, including the following (all the named species or subspecies are attributable to Hintze): *Carolinites genacinaca nevadensis*, *Ischyrotoma blanda*, *I. ovata*, *Isoteloides* sp., *Goniotelus* sp., *Peltabellia*? sp., *Ptyocephalus acclivus*, *Presbynileus elongatus*, *P.* cf. *P. ibexensis*, *Protopliomerops*? *quattuor*, *Psalikilus pikum*, *Pseudocybele altinasuta*, *P. lemurei*, *T. typica* and *T. typica piochensis*. It was in Zone H of Utah that Young (1973) found a bed of silicified limestone, 12.7 cm (5 inches) thick, with a particularly rich trilobite fauna comprising 18 genera and 21 species. The assemblage included *Benthamaspis*, *Carolinites killaryensis utahensis*, *Pseudocybele*, *Ptyocephalus acclivus*, *Shumardia* and *Trigonocerca typica*.

Zone I (Fig. 9)

The sparse fauna recorded by Ross (1949, p. 480; 1951a, p. 28) included only *Retiograptus* sp., *Diparelasma* cf. *D. typicum*, *Hesperonomia* sp. and a single trilobite illustrated, but not described as *Goniotelus* sp. The possibly dubious validity of the zone was hinted at by Ross (1949, p. 480), who stated that "it may eventually be shown to belong in the base of Zone J"; but the unit was retained by

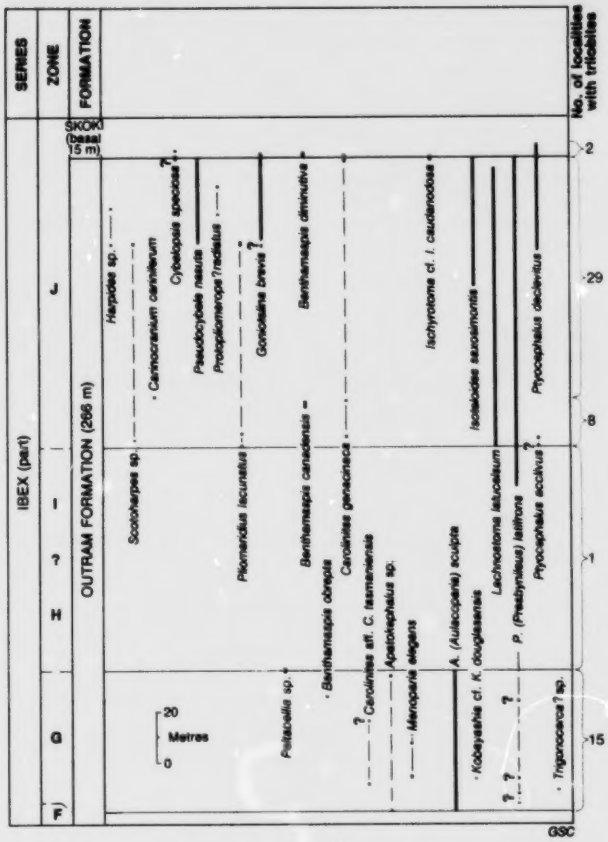


Figure 9. *Chart showing vertical range and age of trilobites in the Outram Formation and basal 6.4 m of the Skoki Formation at Wilcox Pass.*

Hintze (1953, p. 5, 17), who termed it *Paranileus ibexensis* Zone, and the eponymous trilobite was made the type species of *Presbynileus* by Hintze (1954). Hintze's faunal list, more varied than that of Ross, included *Phyllograptus*, *Hesperonomia*, *Syntrophina*? and the trilobites (excluding dubious determinations) *Carolinites genacinaca*, *Isoteloides flexus*, *Kirkella* (now *Ptyocephalus*) *acclivа*, *K. versini*, *Paranileus ibexensis*, *Pseudocybele altinasuta* and *P. lemurei*, all the six last named being described by Hintze (1953).

At Wilcox Pass it proved impracticable to define Zones H and I satisfactorily, and the greater part of the combined interval was barren of macrofossils. The only trilobite is *P.* (*Presbynileus*) *latifrons*, which appears 17 m below the top of the interval and continues through the remainder of the Outram Formation into the lowest Skoki Formation, that is, into Zone J.

Zone J (Fig. 9)

Ross (1949, p. 480) recorded the trilobites *Eleutherocentrus*, *Goniotelus*?, *Kawina* and *Kirkella* (now *Ptyocephalus*) cf. *K. vigilans* and four genera of brachiopods. His later list (Ross, 1951a, p. 27, 28) was more diverse and included, in addition to brachiopods, the following trilobites (all named species attributed to Ross): *Goniotelina* (*Eleutherocentrus*) *williamsi*, *Ptyocephalus* (*Kirkella*)

declevitus, Lachnostoma latucelsum, Carolinites genacinaca, Ischyrotoma [Dimeropygiella] caudanodosa, Kawina sexapugia, Pseudocybele nasuta and *Isoteloides*? sp. The unit was named *Pseudocybele nasuta* Zone by Hintze (1953, p. 5, 18), who listed a more varied fauna that included brachiopods, three cephalopod genera, and the following named trilobites in addition to those given by Ross: *Benthamaspis diminutiva, Cybelopsis* cf. *C. speciosa, Goniotelus brighti, G. brevis, G. wahwahensis, Isoteloides polaris, I.? genalticurvatus, Kawina? webbi, Ptyocephalus* cf. *P. vigilans, Paranileus utahensis, Pseudomera* cf. *P. insolita* and *Trigonocercella acuta*.

Trilobites apparently indicative of Zone J that are found at Wilcox Pass include: *Benthamaspis diminutiva, Carolinites genacinaca, Cybelopsis speciosa, Goniotelina brevis, Ischyrotoma* cf. *I. caudanodosa, Pseudocybele nasuta*, and *Ptyocephalus declevitus*. As shown in Figure 9, the vertical ranges are far from uniform, and owing to dolomitization only the basal 6.4 m of the Skoki Formation yielded fossils. It was found convenient to draw the base of Zone J at the first appearance of *Lachnostoma latucelsum*, which was recorded only from that zone in Utah by both Ross and Hintze. However, the top of the zone is evidently situated higher in the Skoki than that portion yielding macrofossils, judging from the discovery of *G. brevis* (low Zone J in Utah) and *P. declevitus* (middle Zone J in Utah) together in the higher part of the Outram Formation.

Correlation with the British Standard Series

Graptolites are very rare in the Lower Ordovician rocks of the region, and correlation with the British series and corresponding graptolite zones is generally both indirect and imprecise (Fig. 10). International agreement on defining the

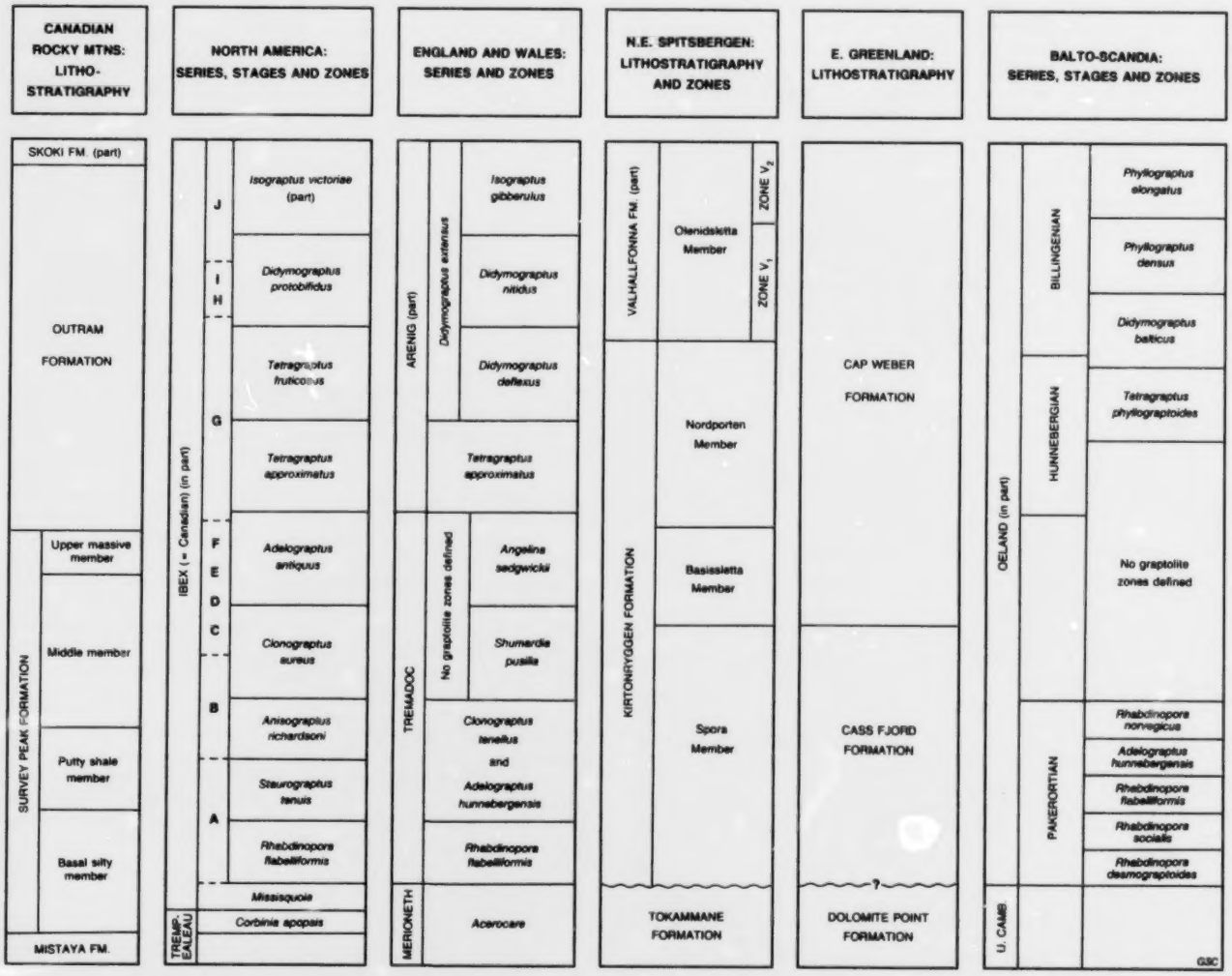


Figure 10. *General correlation of Survey Peak and Outram formations at Wilcox Pass with North American and British sequences of series and zones, and with selected successions elsewhere. Sources of data for columns: England and Wales: Barnes et al. (1981), Ross et al. (1982); N.E. Spitsbergen: Fortey (1980); E. Greenland: Cowie and Adams (1957); Balto-Scandia: Jaanusson (1982). It should be noted that the correlation of the trilobite lettered zones with the various schemes of graptolite zonation is far from precise, and that there is often significant disagreement between the references cited.*

Cambrian-Ordovician boundary has not yet been reached, but the level being concentrated is not far below the first appearance of the cosmopolitan dendroid *Rhabdinopora* (previously *Dictyonema*) *flabelliformis* (Eichwald, 1840) (see various papers in Bassett and Dean, 1982). No graptolites were found during the present work.

In North Wales, 24 km east-southeast of Tremadoc, Rushton (1982) demonstrated that if the Tremadoc Series is defined by the incoming of *R. flabelliformis*, the highest part of the underlying Upper Cambrian (i.e. *Acerocare* Zone) marks the appearance of certain trilobites, including *Araiopleura*, *Beltella*, *Niobella* and *Shumardia*, which have been generally regarded as more typical of the Tremadoc. An analogous situation has been described in western Newfoundland (Fortey, Landing, and Skevington, 1982), where *Missisquoia* and *Symphysurina* appear before *R. flabelliformis*, and Ross et al. (1982, Sheet 1) showed the base of the Tremadoc to be coincident with the top of the *Missisquoia* Zone, the latter unit forming part of the Ibex Series.

Records of *Dictyonema* sp. from Zone A and ?*Dictyonema* sp. from Zone B in the southern Canadian Rockies (Aitken, Fritz and Norford, 1972, p. 38-39) are inconclusive evidence of age; no graptolites are reported from the ambiguous Zone C; *Kainella* in Zone D indicates a link with the Lower Tremadoc of Argentina (Harrington and Leanza, 1957, p. 23-26).

Opinion varies about the correlation of the remaining zones, E to J, represented at Wilcox Pass. Aitken, Fritz and Norford (1972, p. 36) drew the base of the Arenig Series within the lower half of G(2); they correlated Zones H and I with the lower half, and Zone J with approximately the upper half, of the *Didymograptus protobifidus* Zone. On the other hand, Ross et al. (1982) put the base of the Arenig just above the base of G(2). The present evidence is inconclusive, and in Utah the only graptolites recorded by Hintze (1953, p. 14) from G(2) were *Dictyonema* sp. and *Didymograptus*? sp.

In the highest part of the section from which they recorded ?*Trigonograptus* sp. at Mount Wilson, Zone J was assigned to the upper Arenig by Aitken and Norford (1967, p. 180), as well as by Barnes, Jackson and Norford (1976, p. 222) and by Barnes, Norford and Skevington (1981, tables), but it was assigned to the lower Arenig, lower half of the *D. protobifidus* Zone, by Ross et al. (1982, Sheet 1). On the basis of evidence from Spitzbergen, Fortey (1976, p. 271-2) correlated Zone J, characterized by *Carolinites genacinaca*, with the *Didymograptus bifidus* Zone of Berry (1960); the latter subdivision, founded on strata in Texas shown by Bergström and Cooper (1973, p. 313-4) to be of Arenig, pre - *D. hirundo* Zone age, should not be confused with the *D. bifidus* Zone, lower Llanvirn Series, as used in England and Wales.

SYSTEMATIC DESCRIPTIONS

Terminology used is essentially that advocated in the Treatise on Invertebrate Paleontology (Harrington, Moore and Stubblefield, in Moore, 1959). Later terms include eye socle (Shaw and Ormiston, 1964); baccula (Öpik, 1967, p. 53) for a swollen portion of the fixigena in the area bounded by the axial and posterior border furrows; and plectrum (Öpik, 1967, p. 58), defined as a "median, posteriorly directed inbend of the marginal furrow", though sometimes seen as a weakly defined, narrow (sag.) strip immediately in front of the glabella.

Family GERAGNOSTIDAE Howell, 1935

Genus *Geragnostus* Howell, 1935

Type species. *Agnostus sidenbladhi* Linnarsson, 1869.

Subgenus *Micragnostus* Howell, 1935

Type species. *Agnostus calvus* Lake, 1906.

Geragnostus (*Micragnostus*) *chiushuensis* (Kobayashi, 1931)

Plate 1, figures 2-11

Agnostus chiushuensis Kobayashi, 1931, p. 173, Pl. 22, figs. 1-4; Kobayashi, 1939, p. 169.

?*Geragnostus intermedius* Palmer, 1968, p. B24, Pl. 12, figs. 1, 2; Robison and Pantoja-Alors, 1968, p. 776, Pl. 97, figs. 1-10; Stitt, 1977, p. 63, Pl. 3, fig. 1.

Geragnostus mundus (Raymond). Lochman, 1964b, p. 464, Pl. 63, figs. 39-41.

Geragnostus (*Micragnostus*) *chiushuensis* (Kobayashi). Zhou and Zhang, 1978, p. 6, Pl. 1, figs. 1, 2; Zhou and Zhang, 1983, Pl. 1, figs. 14, 15; Lu and Lin, 1984, p. 48, Pl. 1, figs. 4-8; Peng, 1984, p. 315, Pl. 1, figs. 3-7; Qian in Chen et al., 1985, p. 64, Pl. 9, figs. 5-7, 12b; Pl. 19, fig. 3b; Pl. 20, fig. 5a; Duan and An in Duan et al., 1986, p. 30, Pl. 1, figs. 1-3, 4a, 5, 6; Pl. 8, fig. 20b; Pl. 21, fig. 13b; Pl. 22, fig. 7b; Pl. 26, fig. 3b.

Occurrences. All the Wilcox Pass material is from the Survey Peak Formation, and is distributed as follows: basal silty member, GSC localities 89291, 89293, 92229; putty shale member, GSC locality 89280; middle member, GSC localities 92244, 92246. The known range is through about 150 m of strata, but most of the records are from the upper half of the basal silty member and the lowest eighth (approximately) of the putty shale member.

Description and discussion. Kobayashi's type material came from northeast China and as the original illustrations are not very clear, the species is better interpreted from recent Chinese publications (see synonymy), though no detailed account of the specific variability is available. The Albertan material may be compared in particular with that illustrated by Zhou and Zhang (1978) and by Lu and Lin (1984), in which the length (sag.) of the posterior axial lobe of the pygidium exceeds only slightly that of the anterior two segments. In this respect pygidia figured by Peng (1984) differ in having the posterior lobe proportionately longer, occupying 0.6 of the length of the axis.

The Albertan specimens resemble *G. intermedius* Palmer (1968, p. B24), founded on two cephala and four pygidia from the Franconian of Alaska, though the posterior lobe of the pygidial axis is slightly longer, and evidence of a preglabellar median furrow is slight or absent. Specimens from the Tinu Formation of Mexico, said to be of low Tremadoc age, were determined as G. intermedius by Robison and Pantoja-Alor (1968, p. 776), who demonstrated intraspecific variation in the development of a preglabellar median furrow and in the degree of expansion or taper of the posterior axial lobe of the pygidium. They noted also on the pygidium a faint terminal node not mentioned in Palmer's description and arguably present on some examples now figured (Pl. 1, figs. 8, 9). Specimens from Oklahoma described by Stitt (1977, p. 36) and of late Franconian and early Trempealeauan age are similar to, but show a better segmented glabella than, the material from Wilcox Pass.

The present specimens exhibit a small amount of variation in the proportions of the pygidial axis but, particularly in the case of Pl. 1, fig. 11, match closely those from Zone A in the subsurface rocks of Montana assigned by Lochman (1964b, p. 464, Pl. 63, figs. 39-41) to *Geragnostus mundus* (Raymond). Lochman mentioned that one of the cephala showed a faint, preglabellar median furrow. *Geragnostus mundus* was first described, as *Peronopsis munda* Raymond (1925, p. 14, Pl. 1, fig. 7), on the basis of a supposed pygidium from the "Lower Ordovician" at Sinclair Canyon, near Lake Windermere, southeast of Golden, British Columbia; the specimen is apparently a cephalon oriented back to front. *Geragnostus mundus* may prove to be conspecific with *G. chiushuensis* and, if so, would have priority over it, but is in need of revision and the name is best restricted to the holotype for the present. *Geragnostus* aff. *G. mundus* was reported by Kobayashi (1955, p. 365, 475) from his *Symphysurina* fauna in the McKay Group of British Columbia, but the illustrations are insufficient for detailed comparison.

Family DIPLAGNOSTIDAE Whitehouse, 1936

Subfamily PSEUDAGNOSTINAE Whitehouse, 1936

Genus *Neoagnostus* Kobayashi, 1955

Type species. *Neoagnostus aspidoides* Kobayashi, 1955.

Neoagnostus aspidoides Kobayashi, 1955

Plate 1, figure 1

Neoagnostus aspidoides Kobayashi, 1955, p. 473, Pl. 7, figs. 4, 5; Pl. 9, fig. 5; Shergold, 1977, p. 91, Pl. 16, fig. 16.

Holotype. GSC 12745 from the McKay Group, 1.2 km east of Grant Mine, Jubilee Mountain, 45 km northwest of Radium Hot Springs, British Columbia (see Dean, 1978, Fig. 1 for locality map).

Description and discussion. Although no examples of *Neoagnostus* have been collected from the Survey Peak Formation at Wilcox Pass, the holotype of the type species, figured here for comparison with the material of *Geragnostus*, comes from an assemblage that exhibits close affinities with the fauna of the basal silty member or the putty shale member. Distinctive features include the well defined preglabellar median furrow and the bipartite middle segment of the relatively slim, trisegmented glabella. The basal glabellar lobes are proportionately larger than those of any *Geragnostus* found in the Survey Peak Formation, and the surface of the exoskeleton is pitted.

Shergold (1977, p. 79) retained *Neoagnostus* as a distinct genus within the Family Diplagnostidae, Subfamily Pseudagnostinae, together with a *canadensis* group based on *Agnostus canadensis* Billings, 1860 from Lévis, Quebec. He placed *N. aspidoides* in a *bilobus* group based on *Pseudoagnostus bilobus* Shaw (1951, p. 112) from the *Missisquoia* Zone of Highgate Falls, Vermont.

Neoagnostus aspidoides has been recorded from boulders in a conglomerate of the *Symphysurina* Zone in western Newfoundland (Fortey, Landing and Skevington, 1982, p. 105).

Family HARPIDIDAE Whittington, 1950

Subjective synonym. Loganopeltidae Hupé, 1955.

Genus *Harpides* Beyrich, 1846

Type species. *Harpides hospes* Beyrich, 1846.

Harpides sp.

Plate 2, figure 5

Occurrences. The figured specimen GSC 62140 is from GSC locality 92308, 23.5 m below the top of the Outram Formation. Another fragment, GSC 85753, of *Harpides* was found at GSC locality 92297, 37.5 m below the top of the same formation.

Description and discussion. Little comment can be made on such fragmentary material but the characteristic pattern of genal caeca, each ornamented here by a longitudinal row of granules extending on to the cephalic border, is clearly visible and may be generally compared with that described and illustrated by Whittington (1965, Pl. 7, figs. 3, 4) for *Harpides atlanticus* Billings, 1865 from the Table Head Formation (lower Llanvirn Series) of western Newfoundland. Similar structures are found in older species of *Harpides*, such as *H. rugosus* (Sars and Boeck in Boeck, 1838) from the *Ceratopyge* Limestone (Tremadoc Series) of Oslo, refigured by Størmer (1940, p. 146, Pl. 1, figs. 14, 15).

Family HARPETIDAE Hawle and Corda, 1847

Genus *Scotoharpes* Lamont, 1948

Type species. *Scotoharpes domina* Lamont, 1948.

Junior subjective synonyms. *Selenoharpes* Whittington, 1950a, p. 10; *Aristoharpes* Whittington, 1950a, p. 11.

Scotoharpes sp.

Plate 2, figures 1, 3, 6

Occurrences. Found at only two levels in the Outram Formation; GSC localities 92288 and 92297.

Description and discussion. The type and other species of *Scotoharpes* were discussed by Norford (1973), who demonstrated that the genus, which ranges from Lower Ordovician to Middle Silurian, includes forms with either semicircular or suboval cephalic outline, and large or small alae; genal caeca may or may not be present. All these criteria were at one time used to discriminate between *Selenoharpes* and *Aristoharpes*.

The present material is characterized by a poorly defined, small glabella that tapers frontally; the very broad cephalic fringe has its concave dorsal surface turned up near the margin and carries numerous fine pits, incompletely preserved. Basal glabellar lobes are ill defined and opposite them the axial furrows become markedly wider, though no distinct alae are visible. The remaining right eye tubercle, though broken, appears to have been relatively large, connected to the axial furrow by a low, inconspicuous eye ridge. Ornamentation consisting of coarse, anastomosing ridges on the posterior part of the cheek lobes becomes finer anteriorly and laterally. No satisfactory comparison with previously described material was made, and the species may be new.

Family RAPHIOPHORIDAE Angelin, 1854

Genus *Carinocranium* n. gen.

Type species. *Carinocranium cariniferum* n. gen. et sp.

Diagnosis. Cranidium small, transversely subsemielliptical in outline, width two and a half times length. Prominent, longitudinally ridged glabella stands high above moderately convex, quadrant-shaped fixigenae. Pair of long, narrow alae sited opposite posterolateral portions of glabella. Distinct, narrow (sag.) preglabellar field is steeply downturned frontally, bounded by a very small, narrow anterior border. Pair of long (tr.), low, wide (exsag.) eye ridges diverge widely anteriorly from anterolateral margins of glabella; they merge frontally with preglabellar field and are bounded posteriorly by most coarsely pitted portion of fixigenal surface.

Carinocranium cariniferum n. gen. et sp.

Plate 1, figures 12-16

Diagnosis. As for genus.

Holotype. GSC 62139.

Occurrence. 168.5 m above base of Outram Formation, at GSC locality 92293. Associated fauna includes *Benthamaspis*, *Carolinites*, *Lachnostoma* and *P. (Presbynileus)*. Zone J.

Dimensions. Overall breadth of cranidium = 4.3 mm; median length of cranidium = 1.7 mm.

Description and discussion. The new species is known as yet from only the highly distinctive cranidium, and little need be added to the generic diagnosis. The subpyriform glabellar outline, with its distinct pair of alae, resembles that of *Ampyxina* [see Whittington, 1950b, p. 557 for description of *Ampyxina bellatula* (Savage, 1917), the type species] but the latter genus has a smaller glabella, rounded in cross-section when uncrushed, and the fixigenae are both smaller and shorter. The narrow (sag.) occipital ring and the rim-like anterior border, which broadens gradually toward the genal angles, are also similar to those of *Ampyxina*. The massively developed eye ridges and their divergence frontally are not seen in any other described raphiophorid genus. Behind the eye ridges, the axial furrows are broad and deep, but in front of them the same furrows are narrow and shallow, with a pair of anterior pits immediately adjacent to the ridges. No eye tubercles or palpebral lobes have been detected. The preglabellar field and diminutive anterior border may be compared with those of the type species of *Ampyx* and *Lonchodomas*, as well as of *Ampyxina* (see Whittington, 1950b, p. 554, 556, 557; 1959, p. 481).

The almost keel-like form of the glabella, with what appears to be a median tubercle at its apex (though its preservation is not clear), resembles that of the trinucleid genus *Reedolithus* Bancroft, 1933, known from the Balclatchie Group of Girvan (as *Trinucleus subradiatus* Reed, 1903, p. 12) and the *Ampyx* Limestone, Étage 4ab, of Oslo [as *R. carinatus* (Angelin); see Størmer, 1930, p. 30]. A similar shape was described by Størmer (loc. cit.) as being characteristic of immature development stages of *Trinucleus*, and he suggested it might indicate an inverted position for the exoskeleton during swimming.

Family CHEIRURIDAE Hawle and Corda, 1847

?Subfamily PILEKIINAE Sdzuy, 1955

Genus *Tesselacauda* Ross, 1951

Type species. *Tesselacauda depressa* Ross, 1951.

Tesselacauda flabella Kobayashi, 1955

Plate 2, figures 2, 4, 7, 8, 10-12

Tesselacauda flabella Kobayashi, 1955, p. 417, Pl. 2, fig. 8a, b.

Holotype. GSC 12626, an incomplete pygidium figured by Kobayashi (1955, Pl. 2, fig. 8a, b) and now re-illustrated (Pl. 2, fig. 12).

Occurrences. Kobayashi's holotype is purported to be from the McKay Group at GSC locality 7977, "North of first stream from East. North of Brisco Trail. Elevation 5250 feet"; this is also locality 2 of Kobayashi (1955). There the species was said to occur with, among others, *Leiostegium (Evansaspis) glabrum* Kobayashi and *Gonioteloides monoceros* Kobayashi. At Wilcox Pass *T. flabella* was found uncommonly at GSC localities 92253 and 92261; the lower of these is 169 m above the base of the middle member of the Survey Peak Formation, and the other is 21.3 m higher in the same member. The associated fauna includes *Paenebeltella convexa*, *Leiostegium (Evansaspis) ceratopygoides* and the onycophoran mollusc *Ribeiria* (identification kindly provided by J. Pojeta Jr.). These strata are equated with part of Zone E in terms of Ross's (1949, 1951a) lettered zones, and *Tesselacauda* was reported from a broadly similar horizon at Mount Wilson by Norford (in Aitken and Norford, 1967, p. 181).

Dimensions. Pygidium, GSC 62144. Maximum breadth = 12.3 mm, median length = 9 mm, frontal breadth of axis = 4.8 mm.

Description and discussion. Kobayashi's holotype pygidium is slightly compressed dorsally and abraded, and the present material shows more clearly the strong transverse convexity and the well-developed axial, ring, pleural and interpleural furrows. Four axial rings are present, followed by a triangular terminal piece that becomes markedly constricted posteriorly, between the hindmost of four large pairs of pleurae that end in squarely truncated tips. The most characteristic generic feature for the pygidium is the presence of deep, curved pleural furrows, concave forward, on each of the first two pairs of pleurae. The first pleural furrows are deep for the most part but end abaxially at a pair of steeply-declined articulating facets; the anterior band thus delimited is long, narrow (exsag.), fusiform in outline and much smaller than the posterior band, which is constricted at one third its length from the axial furrow and widens (exsag.) toward the blunt tip. The second pleurae are similarly constructed but their pleural furrows extend fully to the preceding interpleura furrows so that the anterior bands are quite discrete, their length (tr.) about two thirds that of the pleurae. The pygidial pleurae become directed progressively more strongly backward from front to rear, and the third and fourth pairs are subparallel to one another, with no sign of pleural furrows.

The holotype pygidium of *Tesselacauda depressa* Ross (1951a, p. 130, Pl. 31, fig. 28) from Zone E in Utah is slightly more than twice as broad as it is long and thus proportionately shorter than that of *T. flabella*, in which the ratio of breadth:length is approximately 3:2. The third and

fourth pleurae of *T. depressa* are relatively smaller than those of *T. flabella* but the anterior bands of the first and second pleurae are larger and their outline is less pointed both adaxially and abaxially.

No cranidium of *T. flabella* was available to Kobayashi and only one fragmentary specimen (Pl. 2, fig. 10) from GSC locality 92261 at Wilcox Pass may reasonably be assigned to the species. It shows the occipital ring, 1p and 2p lateral glabellar lobes and furrows generally similar to those of an incomplete, mature cranidium of *T. depressa* Ross (1951a, Pl. 31, fig. 31), but detailed comparison is not practicable.

Additional material of *T. depressa* from Zone E in Utah was described by Demeter (1973, p. 48) and Terrell (1973, p. 89). In each case, the mature pygidium illustrated agrees with Ross's original illustrations but an immature example (Demeter, 1973, Pl. 1, fig. 14) has the axis proportionately smaller, while the pleurae are relatively longer and end in conspicuous free points.

GSC 62147 (Pl. 2, fig. 9), questionably indentified as a trilobite pygidium, from the Outram Formation at GSC locality 92281, is figured here as gen. et sp. indet. A. The orientation of the specimen is not clear, but the disposition of the furrows shows some resemblance to that on the pleural fields of *Tesselacauda*.

Family PLIOMERIDAE Raymond, 1913

Subfamily CYBELOPSINAE Fortey, 1979

Genus *Cybelopsis* Poulsen, 1927

Type species. *Cybelopsis speciosa* Poulsen, 1927.

Cybelopsis speciosa Poulsen, 1927

Plate 3, figures 6-10;
Plate 4, ?figures 7, 10, 11

Cybelopsis speciosa Poulsen, 1927, p. 305, Pl. 20, figs. 9, 38-43, Textfig. 6; Ross, 1951a, p. 145.

Cybelopsis cf. *C. speciosa* Poulsen. Hintze, 1953, p. 152, Pl. 25, figs. 5, 6, 8-12.

Occurrence. Skoki Formation, 0.7 m above its base, GSC locality 92316. Zone J.

Dimensions. GSC 62149. Overall breadth of cranidium = 19.5 mm; median length of cranidium = 8 mm; frontal breadth of glabella = 6.9 mm; length of combined glabella and occipital ring = 7.3 mm; distance across palpebral lobes = 13.2 mm (estimated).

Description and discussion. Cranidia from Wilcox Pass appear indentical with silicified material from Zone J in Utah illustrated by Hintze (1953). The latter specimens, in turn, include pygidia identical with Poulsen's (1927) material from the Nunatani Formation, Ostracod Limestone, of northwest Greenland. Comparison of cranidia figured by Poulsen is less conclusive owing to their state of preservation. One fragmentary example (Poulsen, 1927 Pl. 20, fig. 40) has 3p glabellar furrows that are scarcely visible (apparently on the internal mould), whereas the same furrows appear deeper on a very small specimen (Poulsen, 1927, Pl. 20, fig. 34), in which the outline of the glabella is slightly more elongated. Corresponding furrows are variably developed on the Canadian specimens and the surface of internal moulds of the glabella is pitted; the occipital ring has a median tubercle, not mentioned in previous accounts.

Hintze (1953, p. 152, Pl. 25, fig. 12c) drew attention to what he termed the "rather unique" form of the pygidial doublure and the manner in which its ventral portion forms a subparabolic ridge set below the bases of the free "pleural spines"; the last-named structures appear to correspond, in fact, to prolongations of only the posterior bands of the pygidial pleurae. These parts of the pygidium closely match the corresponding structures in *Encrinurus* and other encrinurid genera such as *Cornovica* Whittard (1960, p. 122, Pl. 17, fig. 6), and the resemblance emphasises further the close relationship of the Pliomeridae and Encrinuridae.

A hypostoma (GSC 62155, Pl. 4, figs. 7, 10, 11) from the highest part of the Outram Formation, 6.5 m below the base of the Skoki Formation, is referred questionably to the species. The hypostoma of *C. speciosa* was not noted in Poulsen's original description but a silicifed specimen from Utah was assigned to *C. cf. C. speciosa* by Hintze (1953, Pl. 25, fig. 11) and is generally similar to that from Wilcox Pass. Both possess an ovoid median body with weakly developed maculae at the ends of a faint median furrow, but the American specimen is narrower overall and the lateral border is narrower.

Genus *Pseudocybele* Ross, 1951

Type species. *Pseudocybele nasuta* Ross, 1951.

Pseudocybele nasuta Ross, 1951

Plate 6, figures 1-6, 8-11

Pseudocybele nasuta Ross 1951a, p. 138, Pl. 33, figs. 1-14; Pl. 34, figs. 13-17, 21-27; Hintze, 1953, p. 215, Pl. 24, figs. 8-11.

Occurrences. The Wilcox Pass material comes from the highest 37.5 m of the Outram Formation, strata correlated with part of Zone J in Utah, the subdivision from which Ross's (1951) original specimens were obtained. GSC localities include: 92297, 92298, 92300, 92301, 92304, 92305, 92311 and, questionably, 92313.

Description and discussion. All the specimens from Wilcox Pass are fragmentary, often poorly preserved in dark-grey, thin, nodular limestone and frequently associated with *Lachnostoma* and *P. (Presbynileus)*, but are comparable with Ross's silicified material from Utah.

Subfamily PLIOMEROPINAE Hupé, 1953

Genus *Protopliomerops* Kobayashi, 1934

Type species. *Protopliomerops seisonensis* Kobayashi, 1934.

Protopliomerops? radiatus Kobayashi, 1955

Plate 5, figures 1, 3-6

Protopliomerops radiatus Kobayashi, 1955, p. 416, Pl. 2, figs. 5a, b, 6.

Holotype. GSC 12623, a cranidium illustrated by Kobayashi (1955, Pl. 2, fig. 5a, b) and now refigured (Pl. 5, Fig. 1).

Paratype. Pygidium, GSC 12624 (Kobayashi, 1955, Pl. 2, fig. 6).

Occurrences. Kobayashi's type material came from the McKay Group, 35 m (115 ft) below the Mount Wilson Quartzite, at GSC locality 8139, McKay Creek, near Radium Hot Springs, British Columbia (Fig. 1). Also recorded from the type locality (Kobayashi, 1955, p. 364) were, among others, *Kirkella* (now *Ptyocephalus*) and *Ampyx*. At Wilcox Pass *P.? radiatus* was found in Zone J at GSC localities 92307 and 92321, sited 242 m and 253.8 m, respectively, above the base of the Outram Formation.

Dimensions (in mm). (estd.) = estimated.

	GSC 12623	GSC 62157	GSC 62158
Overall breadth of cranidium	28	20	18 (estd.)
Median length of cranidium	12.6	8.5	7.7
Length of combined glabella and occipital ring	11.2	7.7	7
Basal breadth of glabella	7.2	6.3	4.5

Description and discussion. GSC 62158 matches Kobayashi's holotype cranidium almost exactly and shows in addition the form of the left palpebral lobe and eye ridge, which are not preserved on the holotype. These structures closely resemble corresponding parts of the cranidium of *Pliomeridius lacunatus* (see later) but the long, indented frontal glabellar lobe and three well defined pairs of lateral glabellar lobes in *Pliomeridius* preclude confusion. Cranidium GSC 62157 (Pl. 5, figs. 3, 5, 6) resembles the above material except that it has suffered apparently no dorsal compression, so that its appearance is correspondingly more convex. The surviving, left eye ridge of this specimen is continuous with the tall palpebral lobe, and the eye was possibly of pedunculate form; this feature is shared with *Pliomeridius lacunatus* (see Pl. 5, figs. 7, 8).

Protopliomerops subquadratus Kobayashi (1955, Pl. 2, fig. 3) is another pliomerid from the McKay Group at McKay Creek, the holotype coming from GSC locality 8140 [locality 21 of Kobayashi (1955, p. 363), 7.4 m (24 ft)] stratigraphically below the type locality of *P.? radiatus*. The holotype of *P. subquadratus*, now refigured (Pl. 5, fig. 2), lacks most of the surface detail and is almost unrecognizable, though there is a general resemblance to *P.? radiatus* and the two may be synonymous. For the present, the binomen *P. subquadratus* seems best restricted to the holotype.

Whether any of the foregoing material should be assigned to *Protopliomerops* is arguable. The generic name has been used extensively, as by Ross (1951a) and Hintze (1953), several of whose species have since been used to found new genera, but a satisfactory account of the type species *P. selsonensis* Kobayashi (1934, p. 571, Pl. 7, figs. 11b-13; Pl. 8, figs. 16, 17), from the Tremadoc Series of South Korea, is still lacking. Kobayashi's illustrations show the glabella to have a broadly rounded frontal margin and deeply incised 3p glabella furrows, while the eyes are situated well forward, apparently opposite the 3p glabellar lobes. These features are not seen on the Canadian specimens, which are therefore referred only questionably to *Protopliomerops*.

Subfamily uncertain

Genus *Pliomeridius* Leanza and Baldis, 1975

Type species. Pliomeridius sulcatus Leanza and Baldis, 1975.

Pliomeridius lacunatus n. sp.

Plate 3, figures 1-5;
Plate 4, figures 1-3, 5, 6, 8, 9;
Plate 5, figures 7, 8.

Diagnosis. Glabella slightly longer than wide, slightly tapered anteriorly; three subequal pairs of well defined glabellar lobes set well behind anterolateral angles. Anterior border short and rim-like. Frontal glabellar lobe long, with its anterior margin indented medially. Eyes opposite 2p glabellar furrows; strongly developed palpebral lobes continuous with eye ridges. Facial suture imperfectly known but possibly gonatoparian. Surface of glabella smooth; that of fixigenae strongly pitted. Pygidial axis has five well developed axial rings and long terminal piece; pleural fields with five strongly developed pleurae, their posterior bands much the larger and produced to form stout, free points.

Holotype. GSC 62153 (Pl. 4, figs. 1-3, 5, 8).

Paratypes. GSC 62151 (Pl. 3, figs. 1-4), GSC 62152 (Pl. 3, fig. 5), GSC 62154 (Pl. 4, figs. 6, 9), GSC 62159 (Pl. 5, figs. 7, 8).

Occurrences. All the known material of *Pliomeridius lacunatus* is from the Outram Formation. GSC localities at Wilcox Pass include: 92286, 92289, 92298, 92299, 92300 and 92302. The lowest occurrence, at GSC locality 92286, is 149.5 m above the base of the Outram Formation, followed by GSC locality 92289, 4.7 m higher in the succession. After an interval of 75 m, much of it occupied by shale from which no macrofossils were obtained, the species was found throughout a further 2 m of rock. Zone J.

Dimensions. (IM) = internal mould, (EM) = external mould. Holotype cranidium, GSC 62153: overall breadth of cranidium = 20.4 mm (estimated) (IM); median length of cranidium = 9.4 mm (EM); length of combined glabella and occipital ring = 8 mm (EM); frontal breadth of glabella = 4.5 mm (EM); basal breadth of glabella = 5.8 mm (EM).

Paratype cranidium, GSC 62151: overall breadth = 18 mm (estimated) (IM); overall length, including spines = 12.8 mm (estimated) (EM); median length, excluding spines = 9 mm (EM); frontal breadth of axis = 4.2 mm (estimated) (IM).

Description. Glabellar outline is subtrapezoidal, a little longer than wide and slightly tapered frontally. Three subequal pairs of lateral glabellar lobes are bounded by deep, straight glabellar furrows that run slightly back adaxially to leave a median band more than one third the basal glabellar breadth. The frontal glabellar lobe occupies about one third the glabellar length and has an almost straight anterior margin with a shallow, median indentation. The anterior border is narrow (sag.), rim-like, slightly inclined frontally. Strongly developed eye ridges curve posterolaterally from opposite the 3p glabellar furrows and are continuous with well defined palpebral lobes sited opposite the 3p glabellar lobes and 2p glabellar furrows. The fixigenae, excluding the smooth eye ridges, have a coarsely pitted dorsal surface and end at the sharp edge of the wide (exs.) posterior border furrow separating them from the smooth posterior border, a structure that is narrow adaxially and widens abaxially. The anterior branches of the facial suture are moderately convergent frontally; the posterior branches curve back

posterolaterally toward the genal angles, though it is not quite clear whether they cut the margin in a gonatoparian position, as was described for the type species (Leanza and Baldis, 1975a, p. 186).

A single, incomplete pygidium is estimated to be about one and a half times as broad as it is long, including pleural spines. The strongly convex axis stands high above the pleural regions and has a frontal breadth almost a quarter that of the pygidium. Axial furrows are straight, incised, and converge posteriorly at about 35 degrees (estimated). Five axial rings, separated by deep, straight ring furrows, are followed by a narrow, triangular terminal piece that occupies slightly more than one third the length of the axis. The pleural regions curve down abaxially and there are five pairs of pleurae, each divided into a narrow (exs.) anterior band and a broad, conspicuous posterior band that is produced to form a pair of stout border spines. The dorsal surface of each posterior band is longitudinally flat and widens (exs.) toward and beyond the pygidial margin. The posterior bands are separated by flat-bottomed furrows that widen (exs.) toward the lateral margin and represent the anterior bands of the pleurae.

Discussion. *Pliomeridius sulcatus* Leanza and Baldis (1975a, p. 185, Pl. 1, figs. 1-5) was described from the Llanvirn Series of northern Argentina and is thus noticeably younger than the Wilcox Pass material. Both species have a number of characters in common: a relatively long frontal glabellar lobe with anterior margin indented medially; three subequal pairs of lateral glabellar lobes set well behind the anterolateral angles of the glabella; large fixigenae with coarsely pitted surface; pygidium with five distinct axial rings and terminal piece, and pleural lobes composed of five pairs of pleurae that end in large free points. To these a gonatoparian facial suture may possibly be added, though the evidence is inconclusive. The following features distinguish the new species from *P. sulcatus*; the overall glabellar outline tapers anteriorly and there is no widening at the frontal glabellar lobe, a feature of variable development, judging from the illustrations of Leanza and Baldis (1975a, Pl. 1, figs. 1, 5); the median indentation of the frontal glabellar margin is notably smaller; the eyes are larger and set farther back, so that the posterior halves of the fixigenae are much smaller. Differences in the pygidium are more difficult to judge but the pleurae of *P. lacunatus* appear much straighter in dorsal view.

Pliomerid gen. et sp. indet. 1

Plate 6, figure 7

A fragment of a small cranidium, GSC 62167, found in association with *Paenebeltella convexa* Kobayashi, 1955 and *Hyperbolochilus* cf. *H. expansus* Kobayashi, 1955 at GSC locality 92261 (Zone E), is the only pliomerid trilobite yet known from the middle member of the Survey Peak Formation at Wilcox Pass. Though poorly preserved, the specimen shows a subrectangular glabellar outline with three large, almost equisized pairs of lateral glabellar lobes, bounded by narrow, incised glabellar furrows that are only slightly curved. The frontal glabellar lobe is short (approximately one quarter the length of the glabella) and the 3p glabellar furrows cut the glabellar margin at, or slightly behind, the rounded anterolateral angles. There is some resemblance to *Rossaspis* [*Protopliomerops*] *superciliosa* (Ross, 1951a, p. 133; Harrington, 1957, p. 812) from Zone F in the Garden City Formation of Utah, but the material is insufficient for detailed comparision.

Pliomerid gen. et sp. indet. 2

Plate 4, figure 4

An incomplete, very small pygidium, GSC 62156 (Pl. 4, fig. 4) from GSC locality 92276 (Zone G), 18.5 m above the base of the Outram Formation, shows evidence of four or, probably, five axial rings occupying most of the proportionately large axis. The small pleural lobes show traces of four pairs of pleurae ending in slim, free points and there is room for a further pair. Perhaps the closest comparison may be made with the pygidium of *Hintzeia* [*Protopliomerops*] *celsaora* (Ross, 1951a, p. 135, see particularly Pl. 31, fig. 6; Harrington, 1957) from Zone G(1) in the Garden City Formation of Utah.

Family OLENIDAE Burmeister, 1843

Subfamily OLENINAE Burmeister, 1843

Genus *Apoplanias* Lochman, 1964

Type species. *Apoplanias rejectus* Lochman, 1964.

Apoplanias rejectus Lochman, 1964

Plate 8, figures 4-9, 12, 14

Apoplanias rejectus Lochman, 1964a, p. 57, Pl. 14, figs. 25-31; Pl. 15, figs. 15-19; Stitt, 1971, p. 46, Pl. 8, fig. 16; Stitt, 1977, p. 45, Pl. 4, figs. 8, 9; Ludvigsen, 1982, p. 66, Fig. 51M-T, 69K-Q.

Occurrences. All the material is from the basal silty member of the Survey Peak Formation, in which the species was found from 4.7 m to 14.6 m above the base of the unit. GSC localities include: 92207, 92212, 92213, 92214, 92215, 92216 and 92217.

Description and discussion. Lochman's type material came from the subsurface Deadwood Formation in the Williston Basin, Montana, where the species was said to range through 10 feet (3 m) of rock. The strata containing what she termed the *Apoplanias rejectus* faunule were described as "Upper Cambrian - Lower Ordovician passage beds", and although most of the associated fossils were brachiopods, the assemblage included also the dendroid graptolites *Dendrograptus* cf. *D. hallianus* (Prout) and *Callograptus richeyi* Lochman. *Apoplanias rejectus* was regarded by Stitt (1971, p. 13) as being indicative of the *Missisquoia* Zone of Winston and Nicholls (1967, p. 72). Ludvigsen (1982, p. 65) considered the species to be restricted to the upper part of that zone and the lower part of the *Symphysurina* Zone. Lochman (1964a), suggested that *Highgatella*, from the Lower Tremadoc Series, probably developed "from the apparently somewhat earlier *Apoplanias*". Differences between the two genera are certainly small but Stitt (1971, p. 47) pointed out that *Highgatella* has an inflated preglabellar area and elevated palpebral lobes, features not found in *Apoplanias*. Ludvigsen (1982, p. 66) also noted the resemblance of *A. rejectus* to *Highgatella cordilleri* and placed *Apoplanias* in the Oleninae; according to Ludvigsen the pygidium is spinose and not as interpreted by Lochman, but no confirmatory specimen was found at Wilcox Pass.

Subfamily PELTURINAE Hawle and Corda, 1847

Genus *Jujuyaspis* Kobayashi, 1936

Type species. *Jujuyaspis keideli* Kobayashi, 1936.

Jujuyaspis borealis Kobayashi, 1955

Plate 7, figures 1-11;
Plate 8, figures 1-3

Jujuyaspis borealis Kobayashi, 1955, p. 467, Pl. 7, figs. 12, 13a, b; Aitken and Norford, 1967, p. 182; Norford, 1969b, p. 12, Pl. 2, figs. 18-34.

Sphaerophthalmella inexpectans Kobayashi (in part), 1955, p. 464, Pl. 7, fig. 11 only.

?*Jujuyaspis keideli* Kobayashi. Winston and Nicholls, 1967, p. 75, Pl. 12, figs. 20, 23.

Occurrences. Kobayashi's type material was found in limestone of the McKay Goup at GSC locality 8173, at the north end of Steamboat Mountain, near Harrogate, British Columbia; *Gonioteloides*, *Symphysurina*, *Parabolinella* and *Sphaerophthalmella* were reported from the same place. Other localities in the Survey Peak Formation of British Columbia and Alberta were reported by Norford (1969b, p. 12).

At Wilcox Pass *Jujuyaspis borealis* has so far been found to range through the highest 4.0 m of the basal silty member of the Survey Peak Formation, and from 11 m to 12.5 m above the base of the succeeding putty shale member. GSC locality numbers in this section are, in ascending order: basal silty member: 92229, 92231, 89267 and 92232; putty shale member: 89296, 89285, 89283 and 89284.

Dimensions (in mm). (IM) = internal mould; (EM) = external mould; (estd.) = estimated.

	GSC 62168	GSC 62170	GSC 62174	GSC 62177
Overall breadth of cranidium	12.2 (EM) (estd.)	12.8 (EM) (estd.)	-	6.4 (EM)
Median length of cranidium	7.7 (EM)	7.2 (EM)	6.8 (EM)	-
Length of glabella and occipital ring	7.1 (EM)	6.7 (EM)	6.2 (EM)	3.8 (EM)
Basal breadth of glabella	5.2 (EM)	5.4 (EM)	5.2 (EM)	2.7 (EM)
Distance across palpebral lobes	7.3 (EM) (estd.)	9 (EM) (estd.)	8.8 (EM) (estd.)	4 (EM)

	GSC 62171	GSC 62176
Max. breadth of pygidium	7.4 (EM)	6.7 (EM)
Median length of pygidium (excluding half-ring)	3.1 (EM)	3.2 (EM)
Frontal breadth of axis	2.6 (EM)	2.5 (EM)
Median length of axis	2.5 (EM)	2.5 (EM)

Description and discussion. A detailed revision of the species and its relationship to other species of *Jujuyaspis*, especially *J. keideli* Kobayashi (1936a, p. 90; see also Harrington and Leanza, 1957, p. 99) was published by Norford (1969b, p. 12). The genus is known from Argentina, Western Canada, southern U.S.A. and Norway; in all cases the strata are either of Lower Tremadoc age or, in North America, assigned to part of Zone A.

?Subfamily PELTURINAE Hawle and Corda, 1847

Genus *Paenebeltella* Ross, 1951

Type species. Paenebeltella vultulata Ross, 1951.

Paenebeltella convexa Kobayashi, 1955

Plate 8, figures 10, 11, 13;
Plate 9, figures 1-6

Paenebeltella convexa Kobayashi, 1955, p. 468, Pl. 7, fig. 21a, b; Pl. 8, fig. 12; Norford in Aitken and Norford, 1967, p. 181, 194; Dean, 1978, p. 6.

Holotype. GSC 12729 (Pl. 8, figs. 10, 11, 13).

Paratype. GSC 12730.

Occurrences. The holotype came from the McKay Group at GSC locality 7977, north of Brisco Trail, while the paratype was from a similar horizon at GSC locality 8064, south of Whiskey Trail, both localities in British Columbia. The associated fauna (Kobayashi, 1955, p. 366) included, among others *Dimeropygiella*, *Gonioteloides*, *Hystricurus*, *Kainella* and *Tesselacauda*, an assemblage indicative of zones D and E.

In the Survey Peak Formation at Wilcox Pass, *P. convexa* was found to appear 40 m below the top of the middle member, and its highest known occurrence is 26.5 m above the base of the upper massive member. GSC localities are as follows: middle member: 92249, 92257 and 92261; upper massive member: 92264. All are in Zone E.

Dimensions (in mm). (IM) = internal mould; (EM) = external mould; (estd.) = estimated.

	GSC 12729	GSC 62179	GSC 62180	GSC 62181
Overall breadth of cranidium	7.1 (EM)	5.1 (IM)	4.2 (IM) (estd.)	7.3 (IM)
Median length of cranidium	4.7 (EM)	3.5 (IM)	2.6 (EM)	4.3 (IM)
Length of glabella and occipital ring	4 (EM)	3 (IM)	2.1 (EM)	3.5 (IM)
Basal breadth of glabella	2.4 (IM)	1.5 (EM)	1.2 (EM)	2.3 (IM)
Distance across palpebral lobes	5.6 (IM) (estd.)	4.2 (IM)	2.7 (IM) (estd.)	5.5 (IM) (estd.)

Description and discussion. The almost exfoliated holotype cranidium of *P. convexa* shows two pairs of broad (exsag.), shallow indentations that represent 1p and 2p glabellar furrows, structures not reported for *P. vultulata* and not seen on other material of *P. convexa*. The glabellar outline of

P. convexa is more straight sided and bluntly rounded frontally than that of *P. vultulata*, while at least some of the smaller cranidia (Pl. 9, figs. 3, 5, 6) show the glabella narrowing slightly at the occipital furrow.

Ross (1951a, p. 78) commented that the eye ridges were of variable development in *Paenebeltella vultulata* "and obsolete on most cranidia over 8 millimeters long". In the case of *P. convexa*, eye ridges are weakly developed on a few smaller (2.5 mm long) cranidia (Pl. 9, figs. 3, 6) though absent on other small examples and all the largest cranidia. Ross also described a short longitudinal (= median) preglabellar furrow from some, though not all, immature cranidia of *P. vultulata*. Such a structure is not clearly discernible on any of the smallest examples of *P. convexa*, but the largest cranidia invariably show the anterior border furrow and preglabellar furrow linked by a median depression that divides the otherwise almost entire preglabellar field into two halves. The smallest cranidia have a preglabellar field proportionately slightly longer than that of the largest specimens. No librigenae or pygidia definitely assignable to the species have yet been found.

Family PTYCHOPARIIDAE Matthew, 1887

Subfamily EULOMINAE Kobayashi, 1955

Genus *Highgatella* Shaw, 1955

Type species. *Terranovella gelasinata* Shaw, 1951.

Highgatella? *cordilleri* (Lochman, 1964b)

Plate 9, figures 7-10, 12?, 13, 14;
Plate 10, figures 1-10

Euloma cordilleri Lochman, 1964b, p. 464, Pl. 63, figs. 27-30, 31?, 32-34, 36-38; Hu, 1971, p. 104.

Highgatella cordilleri (Lochman). Winston and Nicholls, 1967, p. 73, Pl. 13, figs. 8, 11, 13; Stitt, 1971, p. 47; Derby, Lane and Norford, 1972, p. 506, 507; Stitt, 1977, p. 45, Pl. 6, figs. 1, 2; Dean, 1978, p. 4.

Euloma sp. Norford in Aitken and Norford, 1967, p. 182, 198, 199.

Occurrences. All the Wilcox Pass material is from the basal silty member of the Survey Peak Formation, and the species, as here interpreted, ranges from 16.1 m to 25.7 m above the base of the member. GSC localities are, in ascending order: 89274, 92223, 89273, 89271, 89268, 89272, 89290, 89291, 89276, 89292 and 89275. These occur within the *Missisquoia* Zone and the lowest part of Zone A. The distribution at Wilcox Pass is almost analogous to that described by Lochman (1964b, p. 457) from boreholes in the Deadwood Formation of the Williston Basin, Montana.

As a result of facies changes between Wilcox Pass and Mount Wilson, 45 km to the southeast, *H. cordilleri* at the latter section was reported (Derby et al., 1972, p. 502) from only the highest basal silty member and from the lowest part of the putty shale member.

Description and discussion. Although Lochman's species has, by almost general consent, been assigned to *Highgatella*, nevertheless some misgivings or contradictions have been expressed. Winston and Nicholls (1967, p. 73) considered specimens from Montana and Texas both to be conspecific and to exhibit considerable variation in glabellar outline, convexity of preglabellar field, and relative height of palpebral lobes. On the other hand, Hu (1971, p. 104) regarded all but two of Lochman's type specimens as "typical *Euloma*"; the remainder (Lochman, 1964b, Pl. 63, figs. 31, 35) were placed by him in, respectively, *Highgatella* or *Parabolinella* and *Symphysurina*. According to Shaw (1955, p. 187), when describing the type species, *Highgatella* is characterized by a "highly convex limb in which the border and anterior part of the brim stand vertically". Such features, referring presumably to the preglabellar field and anterior border, have not yet been described for the species *cordilleri*, which is therefore referred only questionably to *Highgatella*. Further re-appraisal must await redescription of the type species, *H. gelasinata* from the *Missisquoia* Zone of Vermont.

All the larger cranidia described by Lochman show a well developed median "boss" or swelling on the preglabellar field; in most of them, the glabellar outline tapers frontally and the axial furrows are less distinct opposite the 1p glabellar lobes. One paratype cranidium (Lochman, 1964b, Pl. 63, fig. 31) has a subrectangular glabellar outline, as do most of the smallest cranidia at Wilcox Pass. According to Lochman, no eye ridges are developed, but these structures are clearly visible on some of the Wilcox Pass cranidia, both large and small (Pl. 9, figs. 9, 14; Pl. 10, figs. 3, 9). Only two pairs of lateral glabellar furrows were reported by Lochman; two pairs are visible on some of the Wilcox Pass cranidia but others show a third pair, usually indistinct but sometimes sharply incised (Pl. 10, fig. 3). Granulation and strong caecal venations on the outer surface of the exoskeleton as described by Lochman are seen on some of, but not all, the present specimens (Pl. 10, figs. 6, 9). An associated left librigena (Pl. 9, fig. 12) resembles two librigenae figured by Lochman (1964b, Pl. 63, figs. 33, 36), but is relatively wider (tr.) and so is referred questionably to the species. When the occipital ring is preserved, a median occipital tubercle is clearly visible, set well forward, immediately behind the occipital furrow.

Family PLETHOPELTIDAE Raymond, 1925

Genus *Plethometopus* Ulrich in Bridge, 1931

Type species. *Bathyurus armatus* Billings, 1860.

Plethometopus obtusus Rasetti, 1945

Plate 10, figures 11-13;
Plate 11, figures 1-7, 9

Plethometopus obtusus Rasetti, 1945, p. 472, Pl. 62, figs. 1, 2; Stitt, 1971, p. 35, Pl. 6, fig. 16. Includes previous synonymy; Taylor and Halley, 1974, p. 24, Pl. 1, figs. 11-14; Ludvigsen, 1982 p. 80.

Occurrences. Found at three localities, GSC localities 92209, 92211 and 92212, ranging from 5.2 m to 9.4 m above the base of the basal silty member of the Survey Peak Formation.

Description and discussion. The small amount of material from Wilcox Pass agrees with previous descriptions of the species and adds nothing to them. Pygidium GSC 62208 (Pl. 11, figs. 5, 6, 9) shows the first segment clearly defined on the internal mould, though not on the external surface of the exoskeleton. A pygidium of *Plethometopus armatus* (Billings, 1860) from Oklahoma illustrated by Stitt (1971, Pl. 6, fig. 18) has the corresponding segment well defined on the external surface and is further distinguished by its proportionately shorter outline that is more broadly rounded posteriorly, with a single large axial ring clearly visible.

Family SOLENOPLEURIDAE Angelin, 1854

Subfamily HYSTRICURINAE Hupé, 1953

Remarks. Fragments of hystricurinid trilobites, though not uncommon in the uppermost fifth of the middle member and the lower half of the upper massive member of the Survey Peak Formation at Wilcox Pass, are generally insufficient for comparison with well preserved material such as that from a much larger stratigraphic interval in Utah described by Ross (1951a) and Hintze (1953). In only a few cases can specific indentification be made with reasonable confidence and most of the material is left in open nomenclature.

Genus *Hystricurus* Raymond, 1913

Types species. Bathyurus conicus Billings, 1859.

Junior subjective synonym. Vermilionites Kobayashi, 1955, p. 452.

Hystricurus oculilunatus Ross, 1951

Plate 14, figures 2, 4, (?)5, (?)6;
Plate 15, figures 1, 2, 12

Hystricurus oculilunatus Ross, 1951a, p. 47, Pl. 10, figs. 1-3, 5, 8, 9, 12; Terrell, 1973, p. 73, Pl. 1, figs. 2, 3, 7, 14-16.

Vermilionites bisulcatus Kobayashi, 1955, p. 453, Pl. 6, fig. 4; Pl. 9, fig. 2.

Occurrences. Survey Peak Formation, middle member, GSC localities 92249 and 92261, 158.7 m and 190.3 m, respectively, above the base of the member. Zone E.

Description and discussion. Ross's description included only the cranidium and librigena. The holotype, a small cranidium, shows the anterior three fifths of the glabella tapering more or less uniformly to the rounded frontal lobe; a larger cranidium (Ross, 1951a, Pl. 10, figs. 8, 9, 12), which should be accorded paratype status, has a slight constriction in front of the centre of the glabellar outline such as is seen in the present material. Cranidia from Wilcox Pass generally show slight evidence of a median, preglabellar depression. The type material came from Zone F in Utah.

Although Kobayashi doubted whether *Vermilionites bisulcatus* belonged to the Solenopleuridae, it has not proved possible to distinguish the holotype cranidium from that of *H. oculilunatus*. *Vermilionites bisulcatus*, from the McKay Group in British Columbia, formed part of Kobayashi's (1955, p. 366) "*Kainella* - *Evansaspis* fauna", which contains elements of both Zone D and Zone E.

Two associated, incomplete pygidia are assigned questionably to the species. Each has a smooth, concave border and one specimen (Pl. 14, fig. 5) shows four, possibly five, pairs of ribs in addition to the anterior half-ribs; the ribs, flat topped and ornamented with tubercles that almost obscure the faint interpleural furrows, end in rounded tips at the border furrow. The other pygidium (Pl. 14, fig. 6) has three well defined, transversely straight axial rings.

Hystricurus cf. *H.* sp. A of Ross, 1951

Plate 14, figures 10, 14

Occurrences. Survey Peak Formation, middle member, GSC 62236 from GSC locality 92260, GSC 62239 from GSC locality 92252, 188.7 m and 166.8 m, respectively, above the base. Zone E.

Description and discussion. The glabellar outline and rim-like anterior border closely resemble those of Ross's (1951a, p. 53, Pl. 9, figs. 31, 34, 37) figured specimen, which came possibly from Zone E in Utah.

Hystricurus cf. *H.* sp. B of Ross, 1951

Plate 14, figures 9, 12, 15

Occurrence. Survey Peak Formation, 172 m above the base of the middle member at GSC locality 92257. Zone E.

Description and discussion. The present cranidium, just over 3 mm long, resembles one (Ross, 1951a, Pl. 10, figs. 18, 19, 23) from Zone E in Utah, but is more tuberculate. Both may be simply immature specimens of *H. oculilunatus*.

Hystricurus sp.

Plate 14, figures 3, 11, 13;
Plate 15, figures 4, 5, 7-11, 13, 14

Occurrences. All the material is from the Survey Peak Formation. GSC 62240, 62241, 62242 and 62243 are from the middle member, GSC localities 92241 (Zone D), 92254 and 92259 (Zone E). GSC 62229, 62237, 62238 and 62245 are from the upper massive member, GSC localities 92263 (Zone E) and 92265 (Zone F).

Description and discussion. The oldest hystricurinids at Wilcox Pass occur in the lowest part of Zone D and all comprise disarticulated, often broken fragments. Some typical examples are illustrated for record purposes.

Genus *Pseudohystricurus* Ross, 1951

Type species. Pseudohystricurus obesus Ross, 1951.

Pseudohystricurus sp.

Plate 14, figures 7, 8

Occurrence. Survey Peak Formation, 181.3 m above the base of the middle member, GSC locality 92258. Zone E.

Description and discussion. Although incomplete, the strongly turned-down front of the cranidium, with the glabella almost overhanging the preglabellar field, may be compared with that of *Pseudohystricurus* sp. from Zone E of Utah figured by Ross (1951a, p. 75, Pl. 16, figs. 26, 27, 31). The specimen, an internal mould, shows only a trace of a longitudinal preglabellar furrow such as is strongly developed on the Utah cranidium, but in both, the posterior two thirds of the glabella are parallel sided, contrasting with the convex-sided glabella of *P. obesus* Ross (1951, Pl. 16, fig. 34), from Zone F in Utah. Ross's cranidium of *Pseudohystricurus* sp. is covered with closely spaced tubercles, but only traces are visible on the exfoliated Canadian example.

?Subfamily HYSTRICURINAE Hupé, 1953

The three genera considered here are *Hyperbolochilus* Ross, 1951a, p. 77; *Metabowmania* Kobayashi, 1955, p. 457;

and *Hillyardina* Ross, 1951a, p. 71. In the Treatise on Invertebrate Paleontology *Hyperbolochilus* was placed in Order and Family uncertain (Henningsmoen in Moore, 1959, p. 523); *Metabowmania* was assigned without comment (Howell and Moore in Moore, 1959, p. 247) to the Emmrichellidae, following Kobayashi; and *Hillyardina* was put in the Hystricurinae (Poulsen in Moore, 1959, p. 278). Cranidia of all three have the following features in common; glabellar outline slightly to moderately tapered, with rounded frontal glabellar lobe; small palpebral lobes set opposite or behind the centre of, and close to, the glabella; preglabellar field well developed, steeply declined, its length up to that of glabella (excluding occipital ring); longitudinal preglabellar furrow generally absent, but weakly developed in *Hillyardina*; surface of exoskeleton usually smooth, but occasionally granulate. In no case is the hypostoma or pygidium known. Kobayashi (1955, p. 424) suggested that *Hyperbolochilus* may be a "relic genus of the Asaphiscidae" or possibly a bathyurid. The material available is insufficient for confident classification of these genera, but the tapered, sometimes small glabella and the often long preglabellar field do not accord with the Bathyuridae, using the criteria listed by Whittington (1953; in Moore, 1959, p. 376). A questionable assignment to the Hystricurinae, though unsatisfactory, is retained for the present.

Genus *Hyperbolochilus* Ross, 1951

Type species. *Hyperbolochilus marginauctum* Ross, 1951.

Diagnosis. Glabellar outline moderately tapered with parabolic frontal lobe; anterior branches of facial suture long, widely divergent; gently convex preglabellar field is notably shorter (sag.) than glabella (excluding occipital ring); anterior border broadly arched in plan, flat and moderately long (sag.); surface of exoskeleton smooth.

Hyperbolochilus cf. *H. expansus* Kobayashi, 1955

Plate 16, figures 7, 9, 10;
Plate 17, figure 7

Occurrences. Survey Peak Formation, middle member; GSC localities 92253 (source of figured specimen) and 92261, respectively 169 m and 190.3 m above base of member. Zone E.

Description and discussion. The species was founded by Kobayashi (1955, p. 422, Pl. 3, fig. 1) on a single cranidium, GSC 12636 now refigured (Pl. 17, figs. 9, 10, 12), from GSC locality 7977 (his locality 2) in the McKay Group. *Hyperbolochilus expansus* formed part of what Kobayashi (1955, p. 366, 369) termed the *Kainella - Evansaspis* fauna, but his "copious fauna" from the type locality includes both *Kainella* and *Leiostegium* (*Evansaspis*), indicative, respectively, of zones D and E. The holotype of *H. expansus* differs from that of *H. marginauctum* in having a proportionately larger, longer glabella and, especially, a longer preglabellar field (compare Pl. 17, fig. 12 with Ross, 1951a, Pl. 17, fig. 27), and the anterior branches of the facial suture diverge forward more strongly.

Hyperbolochilus? sp.

Plate 17, figures 2, 5, 8

Occurrence. Survey Peak Formation, upper massive member, GSC locality 92265, 43.8 m above base of member. Zone F.

Description and discussion. The preglabellar field of the cranidium is proportionately longer than that of *H. expansus*; the glabellar outline is less tapered and more rounded frontally than in either *H. expansus* or *H. marginauctum*. The apparently very steeply declined preglabellar field is considered to be due to longitudinal compression.

Genus *Metabowmania* Kobayashi, 1955

Type species. *Metabowmania latilimbata* Kobayashi, 1955.

Diagnosis. Glabella small, subparabolic in outline; preglabellar field very long (sag.), about as long as glabella (excluding occipital ring) in type species; eyes set well back, behind line through centre of glabella; anterior branches of facial suture long, widely divergent frontally; anterior border small, rim-like, broadly rounded in plan; longitudinal preglabellar furrow absent; surface of exoskeleton smooth or granulate.

Metabowmania latilimbata Kobayashi, 1955

Plate 17, figures 1, 3, 4, 6, 11

Metabowmania latilimbata Kobayashi, 1955, p. 458, Pl. 6, fig. 13; Pl. 8, fig. 9; Pl. 9, fig. 7a, b.

Amechilus tuberculatus Kobayashi, 1955, p. 459, Pl. 6, fig. 11.

Type material. The holotype cranidium of *Amechilus tuberculatus* (GSC 12715, Pl. 17, figs. 3, 6) has an apparently slightly narrower glabellar and less steeply declined preglabellar field than the holotype of *M. latilimbata* (GSC 12713, Pl. 17, figs. 1, 4, 11), but the differences are considered here to be the result of crushing, and the species synonymous. Both holotypes came from GSC locality 7977 (= locality 2 of Kobayashi, 1955, p. 362) in the McKay Group. As noted earlier, the fauna listed from locality 2 by Kobayashi includes trilobites from Zones D and E. The paratype cranidium of *M. latilimbata* is from the same area at GSC locality 8128 (= locality 12 of Kobayashi, 1955, p. 362, 366), from which only *Leiostegium (Evansaspis) glabrum* (now *ceratopygoides*), indicative of Zone E, was recorded.

Amechilus is considered to be an inappropriate genus for Kobayashi's species *tuberculatus*. The type species, *A. palaora* Ross (1951a, p. 112, Pl. 28, fig. 15) was based on four very small cranidia, none more than 2 mm long, which differ from *Metabowmania* in the following respects: cranidium is of low convexity, with almost horizontal preglabellar field; 1p lateral glabellar furrows and faint eye ridges present; anterior border is long (sag.) and flat.

Metabowmania sp.

Plate 16, figures 1, 2, 4-6

Occurrences. Survey Peak Formation: middle member, 190.3 m above base, GSC locality 92261; upper massive member, 9.5 m above base, GSC locality 92263. Zone E.

Description and discussion. The Wilcox Pass cranidia differ only slightly from the holotype of *M. latilimbata*, the surface of which is ornamented with sparsely distributed granules. In GSC 62246 the glabella has straighter sides and its surface

carries larger, denser granules. In GSC 62247 and 62248 the glabellar outline is like that of *M. latilimbata* but the preglabellar field, though not well preserved, is apparently slightly shorter.

Genus *Hillyardina* Ross, 1951

Type species. Hillyardina semicylindrica Ross, 1951.

Diagnosis. Sides of glabella subparallel or slightly convergent forward; outline of frontal glabellar lobe subparabolic; anterior branches of facial suture long, subparallel in type species; preglabellar field well developed, notably shorter (sag.) than glabella and with longitudinal preglabellar furrow; anterior border flat, rim-like. Conspicuous boss on each librigena within intersection of lateral border furrow and posterior border furrow. Surface of exoskeleton tuberculate.

Hillyardina sp.

Plate 16, figures 3, 8

Occurrences. Survey Peak Formation: 190.3 m above base of middle member, GSC locality 92261; 9.5 m above base of upper massive member, GSC locality 92263. Questionably at GSC locality 92260, 188.7 m above base of middle member. All in Zone E.

Description and discussion. Only librigenae were found at Wilcox Pass and these show clearly the swollen area, or boss, sited at the junction of the lateral and posterior border furrows. Ross (1951a, p. 71) distinguished cranidia of the type species of *Hillyardina* and *Hyperbolochilus* on the basis of glabellar shape and the course of the anterior branches of the facial suture (subparallel in the former genus and anteriorly divergent in the latter); he suggested that the librigenal bosses of *Hillyardina* may also be significant for generic discrimination. The present librigenae differ from those of *H. semicylindrica* Ross (1951a, Pl. 16, figs. 2, 8) from Utah in having a much larger boss; this indents the lateral border furrow, which becomes shallower around the abaxial margin of the boss. The lateral border is narrower in the Canadian specimens and the margin curves forward and inward less strongly. *Hillyardina* was recorded only from Zone F by Ross (1951a, p. 72), but from Zones E and F by Hintze (1953, p. 10, 162, Pl. 8, figs. 5, 6). The latter's illustrations of *H.* sp. A include an incomplete cranidium with smooth surface, long preglabellar field with no trace of longitudinal preglabellar furrow, and widely divergent anterior branches of the facial suture, features more suggestive of *Hyperbolochilus* than of *Hillyardina*; however, the associated librigena shows both a boss and a strongly divergent facial suture. Evaluation of these characters as generic criteria requires further material.

A single right librigena, GSC 62228 (Pl. 14, fig. 1) from Zone E in the upper massive member of the Survey Peak Formation, is of a type that would not be inappropriate for *Hystricurus* or *Hillyardina* (compare Ross, 1951a, Pl. 17, fig. 25). But the surface of the genal field carries coarse ornamentation of anastomosing ridges, directed almost longitudinally, unlike that of any cranidia in this part of the succession and the specimen is recorded only as Genus and species undetermined D.

Family BATHYURIDAE Walcott, 1886

Genus *Goniotelina* Whittington and Ross in Whittington, 1953

Type species. Eleutherocentrus williamsi Ross, 1951.

Junior subjective synonym. Omuliovia Chugaeva, 1962, p. 61. The cranidium of the type species, *O. mira* Chugaeva (1962, p. 62, Pl. 9, figs. 1-7; see also Chugaeva et al., 1973, p. 73, Pl. 5, figs. 1-3; Pl. 6, figs. 1-6) has a cranidium indistinguishable from that of *Goniotelina*. Pygidia assigned to *O. mira* differ only slightly from *Goniotelina*: the pleural fields lack pustulose ornamentation; the longer (tr.) ribs carry more strongly impressed interpleural furrows; and the posterior margin is more rounded, though one specimen (Chugaeva et al., 1973, Pl. 5, fig. 1) has a suggestion of a blunt terminal point.

Goniotelina brevis (Hintze, 1953)

Plate 26, figures 1-14; Plate 27, figures 1-3

Goniotelus brevus Hintze, 1953, p. 159, Pl. 26, figs. 7-10.

Goniotelina brevus (Hintze). Whittington and Ross in Whittington, 1953, p. 666.

Goniotelina brevis (Hintze). Ross, 1970, p. 88.

Occurrences. At Wilcox Pass, *G. brevis* ranges through the topmost 34 m (questionably the topmost 37 m) of the Outram Formation and the lowest 0.7 m of the Skoki Formation. GSC localities in the Outram Formation there include the following, in ascending order: 92998?, 92301?, 92302?, 92303, 92309, 92321, 92323, 92311, 92315, 92324 and 92314. Skoki Formation: GSC locality 92316. Zone J.

Dimensions (in mm). (IM) = internal mould; (EM) = external mould; (estd.) = estimated.

Cranidium	GSC 62317	GSC 62318	GSC 62321	GSC 62322
Overall breadth	-	14 (IM) (estd.)	12 (IM) (estd.)	7.6 (IM) (estd.)
Median length	3.8 (IM)	9.5 (IM) (estd.)	-	4.9 (IM)
Length of glabella and occipital ring	3.3 (IM)	8.6 (IM)	8.7 (IM)	4.2 (IM)
Basal breadth of glabella	2 (IM)	4.5 (IM)	4.4 (IM)	2.2 (IM)
Distance across palpebral lobes	3.7 (IM) (estd.)	10.5 (IM) (estd.)	10.4 (IM) (estd.)	5.1 (IM) (estd.)
Length of palpebral lobes	-	3.7 (IM) (estd.)	3.4 (IM) (estd.)	1.7 (IM) (estd.)

Pygidium	GSC 62319	GSC 62328
Maximum breadth	5.8 (IM) (estd.)	8 (IM) (estd.)
Median length (excluding half-ring and terminal spine)	3.4 (IM)	4.3 (IM)
Length of axis	2.7 (IM)	3.7 (IM)
Frontal breadth of axis	1.9 (IM) (estd.)	2.5 (IM) (estd.)

Description and discussion. The present specimens match closely the type material from Zone J in Utah but exhibit some variation in the development of tubercles. For example, Pl. 26, fig. 6 of this paper resembles a paratype illustrated by Hintze (1953, Pl. 26, fig. 7a, b), but in other cranidia the tubercles are slightly larger and less crowded.

Pygidia from Wilcox Pass agree well with the holotype (Hintze, 1953, Pl. 26, fig. 8a, b), all having four transversely straight axial rings, the third and fourth of which are sometimes less well defined, and a subsemicircular terminal piece. Particularly conspicuous is the convexity of the pleural fields, divided by deep pleural furrows to produce three pairs of unfurrowed ribs and a pair of anterior half-ribs. The surface of the axis and pleural fields is strongly ornamented with tubercles, often coarse. The lateral border, as wide (tr.) as the pleural fields, is sometimes apparently smooth but may be ornamented with incipient tubercles of flattened appearance that produce a scale-like surface (Pl. 26, fig. 5). In all sufficiently well preserved examples, the terminal spine is small and upturned, situated immediately above the tip of the transversely arched posterior margin (Pl. 27, fig. 1) and set well behind the terminal piece of the axis.

Goniotelina? sp.

Plate 27, figures 8, 10, 11, 13

Occurrence. Outram Formation, 253.8 m above its base, GSC locality 92321.

Description and discussion. An incomplete cranidium, estimated length 14 mm, has a glabella closely resembling that of *Goniotelina* in convexity and outline. Apart from some traces of incipient tubercles on the posterior half of the occipital ring, ornamentation (as shown by both internal and external mould) comprises fine pits on the glabella and frontal area, and subparallel terrace lines along the narrow (sag.), rim-like anterior border. The course of the anterior branches of the facial suture and, particularly, the form of the frontal glabellar lobe, which almost attains the anterior border furrow and is bounded by a preglabellar furrow that becomes nearly obsolete at the axial line, suggest that the specimen may be assigned questionably to *Goniotelina*.

Genus *Gonioteloides* Kobayashi, 1955

Type species. Gonioteloides monoceros Kobayashi, 1955.

Gonioteloides monoceros Kobayashi, 1955

Plate 27, figures 4-6

Gonioteloides monoceros Kobayashi, 1955, p. 447, Pl. 6, figs. 17a, b, 18a, b; Dean, 1978, p. 7.

Gonioteloides cf. *G. monoceros* Kobayashi. Berg and Ross, 1959, p. 117, Pl. 21, figs. 8, 9.

Gonioteloides monoceras (sic) Kobayashi. Norford in Aitken and Norford, 1967, p. 181.

Type material. Kobayashi's holotype and paratype pygidia, GSC 12697 and 12698, respectively, came from the McKay Group at GSC locality 7977. GSC 12697 is refigured here (Pl. 27, figs. 4, 5).

Occurrence. Survey Peak Formation, middle member, GSC locality 92256.

Description and discussion. Although the present pygidium from Wilcox Pass is both fragmentary and dorsally compressed, the form of the first three axial rings and furrows, followed by a V-like fourth ring furrow that is deepest medially, and the truncated pleural regions, traversed by deep pleural furrows that are 'stepped' in relation to the ring furrows, match those of the holotype.

The ambiguity of Kobayashi's (1955, p. 365) statement that *G. monoceros* occurs at two levels, Zone B and Zone E, within the McKay Group has been reviewed elsewhere (Dean, 1978, p. 7). Both Berg and Ross (1959, p. 118-119) in Colorado, and Norford (in Aitken and Norford, 1967, p. 181) at Mount Wilson, Alberta, reported the species only from strata assigned to Zone E. The specimen from Wilcox Pass also occurs in Zone E, where it is accompanied by *Leiostegium* (*Evansaspis*) *ceratopygoides*.

Genus *Peltabellia* Whittington in Moore, 1959

Type species. Jeffersonia peltabella Ross, 1951.

Peltabellia sp.

Plate 40, figures 10, 14, 15

Occurrence. Outram Formation, 60.5 m above its base, at GSC locality 92284. Zone G.

Dimensions of pygidium. Overall breadth = 10.8 mm, median length = 6 mm, frontal breadth of axis = 2.4 mm, length of axis = 3 mm.

Description. The single, incomplete pygidium is broadly semielliptical in outline, breadth slightly less than twice length. The low, straight-sided, gently tapered axis occupies between one fifth and one quarter of the overall breadth and half the median length; immediately behind its blunt tip, and outside the convex pleural fields, the dorsal surface drops sharply to the very large, gently declined lateral border, which narrows (tr.) only slightly toward the anterolateral angles. The anterior half of the axis carries two ill-defined, transversely straight axial rings; the pleural fields have four pairs of pleurae, with only shallow pleural and interpleural furrows that end at the change in slope marking the lateral border.

Discussion. The holotype pygidium of *P. peltabella*, described by Ross (1951a, Pl. 17, figs. 19, 21), bears a considerable overall resemblance to the present specimen, but differs in the following respects: the median length is proportionately greater (two thirds of breadth); the axis, though of similar form, is a little longer; the pleural fields are slightly smaller and more triangular in outline; and the pair of anterior half-ribs is more strongly defined.

Whittington (1953, p. 662) suggested that *Peltabellia* was probably represented by silicified specimens from Utah described as *Jeffersonia*? sp. from Zone G(1) (Hintze, 1953, p. 175, Pl. 9, figs. 8, 11, 12) and as *Jeffersonia* sp. from Zone G(2) (Hintze, 1953, p. 174, Pl. 10, figs. 7-10). In each case Hintze's material included a pygidium in which, among other differences, the lateral border is considerably narrower than in the type species, and the assignment to *Peltabellia* seems dubious.

The pygidium of *Peltabellia willistoni* Lochman (1966, p. 542, Pl. 62, figs. 10, 11), from Zone G in the subsurface Deadwood Formation of Montana, is proportionately longer than the present specimen, has a larger, longer axis, and the adaxial parts of the pleural fields carry only three pairs of ribs in addition to the pair of anterior half ribs.

?Family LECANOPYGIDAE Lochman, 1953

Genus *Benthamaspis* Poulsen, 1947

Type species. Benthamaspis problematica Poulsen, 1946.

Junior subjective synonym. Oculomagnus Lochman, 1966.

Remarks. The systematic position of *Benthamaspis* is uncertain. Hintze (1953, p. 142) did not make any suggestion as to which family might receive it, and in the Treatise on Invertebrate Paleontology, Lochman-Balk (in Moore, 1959, p. 295) placed it in the Komaspididae. In his original description, Poulsen regarded the nileid-like features as superficial and argued that the intramarginal facial sutures of *Nileus* and *Symphysurus* were sufficient to differentiate those genera from *B. problematica*, in which there was apparently room for a large rostral plate. More recently Fortey (1979, p. 100), in describing additional species from Zone H in western Newfoundland, assigned *Benthamaspis* tentatively to the Lecanopygidae, a course followed questionably here. He also placed *Oculomagnus* Lochman, 1966 (type species *O. obreptus* Lochman, 1966) in the synonymy of *Benthamaspis* on the basis of Newfoundland species showing characters intermediate between those of *B. obrepta* and *B. problematica*. At Wilcox Pass, *B. obrepta*, characterized by a tapered glabellar outline that is well defined frontally, wide interocular areas, a distinct anterior border, and a moderately declined preglabellar field, was found at only a single locality in Zone G, in the lower part of the Outram Formation. No examples of *Benthamaspis* were found in beds assigned to zones H and I, which are mostly poorly fossiliferous, and the genus was next encountered as *B. canadensis*, at two localities low in Zone J, followed by *B. diminutiva* higher in Zone J, at two localities in the topmost Outram Formation and lowest Skoki Formation.

If the above species, together with the Zone H species from Newfoundland, form a genuine evolutionary sequence, the changes in morphology between zones G and J involve: progressive loss of definition of the front of the glabella; diminution of the preglabellar field, so that the small anterior border is overhung by the frontal glabellar lobe; narrowing of the interocular areas; glabellar outline becoming progressively less tapered, and eventually parallel-sided. Species from zones H and J also show a slight constriction of the glabellar outline in front of the occipital furrow, approximately where 1p glabellar furrows might be expected; no such constriction is visible in *B. obrepta*. All the above features may have biostratigraphic potential.

Benthamaspis obrepta (Lochman, 1966)

Plate 27, figures 7, 9, 12, 14

Undetermined genus and species C. Ross, 1951a, p. 120, Pl. 29, figs. 20, 21, 24.

Oculomagnus obreptus Lochman, 1966, p. 541, Pl. 62, figs. 1-7. Genus and species undet. B. Hintze, 1953, Pl. 13, fig. 14.

Oculomagnus sp. Norford in Aitken and Norford, 1967, p. 191.

Benthamaspis obrepta (Lochman, 1966). Fortey, 1979, p. 102.

Occurrence. Outram Formation, 50.2 m above the base, at GSC locality 92281. Associated fauna includes *A. (Aulacoparia)*, *P. (Presbynileus)* and the onychophoran mollusc *Ribeiria* (specimen determined by J. Pojeta Jr.). Zone G.

Dimensions. (IM) = internal mould; (EM) = external mould. Median projected length of cranidium = 3.9 m (IM); median length of combined glabella and occipital ring = 2.9 mm (IM); maximum breadth of glabella = 2.4 mm (EM); distance across palpebral lobes = 5.1 mm (IM).

Description and discussion. The single silicified cranidium from Zone G(1) in Utah figured originally by Ross (see above) was employed as holotype by Lochman, whose description of both genus and species was founded on it, supplemented by three cranidia and a pygidium from the subsurface Deadwood Formation in the Williston Basin, Montana. Thus, although Lochman regarded the latter specimens as plesiotypes, they should be interpreted as paratypes.

The cranidium from Wilcox Pass is almost exfoliated, and the presence or absence of the holotype's distinctive ornamentation of ridges forming a Bertillon pattern cannot be demonstrated, but there are otherwise no apparent differences. One may note that the apparently steep anterior declination of the preglabellar field in Lochman's Montana specimens is the result of crushing; both the holotype and the present material have the preglabellar field only moderately declined. Particularly distinctive features are the narrow (sag.), rim-like anterior border and the long, narrow (tr.) palpebral lobes, the flat upper surface of which is level with that of the fixigenae. The median quarter of the occipital furrow deepens a little and delimits a small, slightly depressed area at the front of the occipital ring; the depression appears to be an original feature and is not visible on the external surface as exemplified by the holotype.

Benthamaspis canadensis n. sp.

Plate 19, figures 6, 10; Plate 20, figures 1-8

Benthamaspis sp. Norford in Aitken and Norford, 1967, p. 190.

Benthamaspis cf. *B. problematica* Poulsen. Dean, 1978, p. 9.

Diagnosis. Benthamaspis species with cranidial outline subsemielliptical, its median length about 0.7 of maximum breadth, measured across palpebral lobes. Combined glabella and occipital ring parallel-sided with breadth equal to about 0.55 that of the cranidium and 0.8 its median length. Straight axial furrows die out anteriorly, and front of glabellar region is continuous with that of fixigenae. Palpebral lobes very long, more than two thirds length of cranidium, and poorly differentiated, becoming progressively more convex in plan from front to rear. Posterior halves of fixigenae are very small. Shallow, transversely straight occipital furrow deepens medially, especially on internal mould.

Pygidium bluntly and broadly rounded in plan, widest (tr.) frontally, with median length approximately 0.8 of the maximum breadth. Axis small, strongly convex, triangular, with traces of two axial rings; length slightly less than half that of pygidium. Short postaxial ridge present; doublure

very wide (sag.). Pleural regions show well defined first segment that forms pair of large, anterolateral facets. Surface of cranidium ornamented with closely spaced Bertillon pattern of narrow ridges; similar ridges on pygidium are more transverse in direction and more widely spaced.

Holotype. GSC 62269 (Pl. 20, figs. 2, 3, 6).

Paratypes. GSC 62265 (Pl. 19, figs. 6, 10), GSC 62268 (Pl. 20, fig. 1), GSC 62270 (Pl. 20, figs. 4, 5, 7, 8).

Occurrences. Outram Formation. The type specimens are from dark, nodular weathering limestone at GSC locality 92290, 165 m above the base of the formation; the species was found also at GSC locality 92293, 3.5 m higher in the same formation. Zone J.

Dimensions (in mm). (IM) = internal mould; (EM) = external mould.

	GSC 62268	GSC 62269	GSC 62270
Median length of cranidium	2.8 (EM)	3.3 (EM)	-
Maximum breadth of cranidium (across palpebral lobes)	4.1 (EM)	4.5 (EM)	-
Maximum breadth of glabella	2.3 (EM)	2.4 (EM)	-
Maximum breadth of pygidium	-	-	3.7 (EM)
Median length of pygidium	-	-	2.6 (IM)
Length of pygidial axis (excluding post-axial ridge)	-	-	1.1 (IM)

Discussion. It has been found convenient to combine the discussion of *Benthamaspis canadensis* with that of *B. diminutiva.*

Benthamaspis diminutiva Hintze, 1953

Plate 20, figures 9-13

Benthamaspis diminutiva Hintze, 1953, p. 142, Pl. 13, figs. 9-12.

Benthamaspis cf. *B. diminutiva* Hintze. Dean, 1978, p. 9.

Occurrences. Outram Formation, 1 m below its top; GSC locality 92324. Skoki Formation, 0.7 m above base; GSC locality 92316. Both in Zone J.

Dimensions (in mm).

	GSC 62272	GSC 62273
Median length of cranidium	-	2.3
Maximum breadth of cranidium (across palpebral lobes)	-	3.3
Maximum breadth of glabella	-	1.6
Maximum breadth of pygidium	2.0	-
Median length of pygidium	1.5	-
Length of axis	0.9	-

Description and discussion. In the present account it is preferred to emphasize the salient features of *Benthamaspis canadensis* in a long diagnosis rather than repeat much of the information in a detailed description. *Benthamaspis problematica* Poulsen (1946, p. 325, Pl. 22, figs. 14-16), though founded on only a single, incompletely preserved cranidium from the Nunatami Formation (?) of Ellesmere Land, clearly resembles the new species and it is more practical to stress features useful in distinguishing between the two. Cranidial proporations differ only slightly, but in plan view the outline of *B. problematica* is more bluntly rounded and a break in curvature marks the front of each semielliptical palpebral lobe; in *B. canadensis* the combined palpebral lobes and fixigenae become notably wider posteriorly, almost to the posterior border furrow, and their outline, with that of the front of glabella, forms an unbroken parabolic curve. Poulsen's illustration of the lateral view of *B. problematica* suggests that the front of the glabella of the Arctic species is more strongly arched and stands higher in relation to the axial furrows; conversely the occipital ring and rear of the glabella are proportionately higher in *B. canadensis* (compare Pl. 20, fig. 2 with Poulsen's Pl. 22, fig. 16). Apparently more significant are the posterior branches of the facial suture. In *B. canadensis* these are very short and the diminutive triangular projections formed by the hindmost parts of the fixigenae do not extend laterally as far as do the palpebral lobes, whereas in *B. problematica* the corresponding structures extend well beyond (compare Pl. 20, figs. 1, 6 with Poulsen's, Pl. 22, fig. 14).

Benthamaspis distincta Young (1973, p. 98, Pl. 1, figs. 9-17), from Zone H (= Arenig Series in part) of Utah, was founded on only cranidia and librigenae. The glabellar outline is more convex forward and the palpebral lobes are narrower than in *B. problematica* or *B. canadensis*, while the anterior border is larger and better defined. Although Young claimed that the occipital furrow of the Utah species is distinct compared with that of *B. problematica*, Poulsen's illustrations of the latter species do not, in fact, show this structure. The material from Wilcox Pass suggests that the furrow should be interpreted with discretion as it is much more strongly developed on an internal mould than on the corresponding external surface.

Of the species from Zone H in western Newfoundland, *Benthamaspis gibberula* (Billings, 1865) (Fortey, 1979, p. 100, Pl. 34, figs. 1-15) has the preglabellar furrow effaced but the anterior border is more strongly developed than in *B. canadensis*, the posterior branches of the facial suture are longer, and the glabellar outline is often tapered, particularly on larger cranidia; even on smaller cranidia the parallel-sided portion of the glabella is shorter than in the new species, and the frontal parts of the axial furrows are more distinct. *Benthamaspis conica* Fortey (1979, p. 102, Pl. 35, figs. 1-10) has a distinct preglabellar furrow and tapered glabellar outline. The pygidium of *B. canadensis* is proportionately longer and more broadly rounded than that of the above species; the axis is both shorter (about 0.4 of pygidial length, excluding articulating half ring) and more pointed than in most of the Newfoundland examples, though that of *B. gibberula* appears to show some variation in length.

The silicified type material of *Benthamaspis diminutiva* Hintze (1953, p. 142, Pl. 13, figs. 9-12), from Zone J of Utah, is closely comparable with the specimens figured here from the highest Outram and basal Skoki formations at Wilcox Pass. The pygidium of *B. canadensis* is easily distinguished from that of *B. diminutiva* by its proportionately much smaller, triangular axis and its more transversely straight anterior margin, with the anterolateral angles set farther forward. Other striking features of *B. canadensis* are the well defined first pygidial pleurae and the very wide

doublure. The first of these structures is seen also on "unassigned pygidia Nos. 9 and 10" figured by Young (1973, Pl. 6, figs. 17, 18, 20, 21); these two specimens may be assigned to *Benthamaspis* but differ from each other in details of the doublure (which is wide), and both lack the post-axial ridge of *B. canadensis*.

Family TELEPHINIDAE Marek, 1952

Junior subjective synonym. Tafnaspididae Leanza and Baldis, 1975.

Genus *Carolinites* Kobayashi, 1940

Type species. Carolinites bulbosa Kobayashi, 1940.

Junior subjective synonyms. Dimastocephalus Stubblefield, 1950; *Keidelia* Harrington and Leanza, 1957; *Tafnaspis* Leanza and Baldis, 1975a.

There is some uncertainty about the systematic family position of *Carolinites*. Fortey (1975, p. 94) preferred to employ the Telephinidae in a broad sense to include not only *Telephina* Marek, 1952 and *Carolinites* but also, among others, *Goniophrys* Ross, 1951a and *Carrickia* Tripp, 1965. On the other hand Legg (1976, p. 5), in a revision of the type species, followed Stubblefield (1950) and Whittington (1965, p. 373) in assigning *Carolinites* to the Komaspididae Kobayashi, 1935. Legg noted the close resemblance of *C. bulbosus* to *C. genacinaca* Ross, 1951 and suggested that the two may prove to be synonymous. More recently, Jell and Stait (1985, p. 40, 41) retained *Carolinites* in the Telephinidae and demonstrated that *C. tasmaniensis* (Etheridge, 1919, p. 392), from the Caroline Creek Sandstone of Tasmania, is a senior subjective synonym of both *C. bulbosa* and *C. genacinaca nevadensis* Hintze, 1953; they also considered *C. genacinaca* to be a separate species, and their interpretation is followed here.

Carolinites genacinaca Ross, 1951

Plate 18, figures 2, 3, 5-7, 10;
Plate 19, figures 1-5, 7, 8

Carolinites genacinaca Ross, 1951a, p. 84, Pl. 18, figs. 25, 26, 28-36; Hintze, 1953, p. 145, Pl. 20, figs. 7-9; Legg, 1976, p. 5; Jell and Stait, 1985, p. 41.

Carolinites genacinaca genacinaca Ross, 1951a. Fortey, 1975, p. 112, Pl. 37, figs. 1-15; Pl. 38, figs. 1-3; Fig. 13. Includes synonymy.

Occurrences. Outram Formation, topmost 111.8 m, GSC localities, in ascending order: 92289, 92292, 92293, 92311, 92324, 92315. Skoki Formation, 0.7 m above the base, GSC locality 92316. Zone J.

Description and discussion. The present material is fragmentary and adds nothing to previous, detailed descriptions. All the Outram specimens are from thin beds of dark grey, nodular limestone interstratified with dark grey shale. The Skoki specimens are preserved in thinly bedded, light grey calcarenite.

Carolinites aff. *C. tasmaniensis* (Etheridge, 1919)

Plate 18, figures 4, 8, 9, 11, 12

Occurrences. All the figured specimens are from 15 m above the base of the Outram Formation at GSC locality 92275. Possibly conspecific material was found rarely at GSC locality 92280, 40.5 m above the base of the same formation. Zone G (undivided).

Description and discussion. The large (median length of combined glabella and occipital ring = 5.7 mm), incomplete cranidium now illustrated (Pl. 18, figs. 9, 12) agrees closely with the holotype of *C. genacinaca nevadensis* Hintze (1953, p. 146, Pl. 20, fig. 3), synonym of *C. tasmaniensis* (see Jell and Stait, 1985, p. 41), from Zone H in Nevada, including such features as the slim, elongated form of the bacculae and the slight indentations of the glabellar sides. In a paratype pygidium figured, but not commented on, by Hintze (1953, Pl. 20, fig. 5a, b) the first two axial rings are separated by deep wide (sag.) ring furrows, followed by a narrower (sag.), shallower, third ring furrow and a suggestion of a fourth. Pygidia of *C. tasmaniensis* illustrated by Jell and Stait (1985, Pl. 15, fig. 14-17) have two strongly defined axial rings and a third, which is variably developed. The present specimen has the first two axial rings well defined as in *C. tasmaniensis*; the third ring furrow is well developed laterally; and the fourth ring furrow is slit-like, incised on the steeply declined hindmost part of the axis, the terminal piece of which grades into a triangular group of tubercles on the post-axial area (Pl. 18, fig. 8). Tubercles are visible also on the surface of the axial rings. The specimens may represent a new subspecies, but are insufficient for formal diagnosis.

Family LEIOSTEGIIDAE Bradley, 1925

Genus *Leiostegium* Raymond, 1913

Type species. Bathyurus quadratus Billings, 1860.

Remarks. In an earlier paper dealing with the stratigraphy of Wilcox Pass (Dean, 1978, p. 6), *Leiostegium* was employed as a subgenus of *Lloydia* Vogdes, 1890, as recommended by Lochman (1965, p. 477; 1966, p. 533), who cited unpublished evidence by F. Rasetti which was said to show that the type species of *Lloydia* and *Leiostegium* grade into one another. This claim remains unsubstantiated and for the present it is proposed that Ross (1970, p. 73-74) be followed in restricting *Lloydia* to its type species, *Bathyurus bituberculatus* Billings, 1865, and using *Leiostegium* to include a number of subgenera such as *Perischodory* Raymond, 1937 and *Manitouella* Berg and Ross, 1959, as well as *Evansaspis*, introduced in the same sense by Kobayashi (1955, p. 420), and perhaps *Marcouella* Shaw (1966, p. 1320).

Subgenus *Leiostegium* Raymond, 1913

Leiostegium (*Leiostegium*) *valmyense* (Lochman, 1966)

Plate 21, figures 4, 7, 10

Leiostegium sp. Ross, 1958, p. 566, Pl. 83, figs. 19, 20.

Lloydia (*Leiostegium*) *valmyensis* Lochman, 1966, p. 544, Pl. 62, fig. 12.

Leiostegium valmyense Lochman. Aitken and Norford, 1967, p. 181.

Occurrences. Survey Peak Formation, 73.9 m above the base of the upper massive member, GSC locality 92267.

Ross's (1958) original material, which provided the holotype and paratype of Lochman's species, came from a limestone interbedded with pillow lava in the Valmy Formation of Nevada. Lochman (1966) considered a pygidium from the subsurface Deadwood Formation, Williston Basin, Montana to be conspecific and postulated that both sets of material came from Zone G(1). The Wilcox Pass specimens are from Zone F.

Description and discussion. The cranidium figured by Ross (1958, Pl. 83, fig. 19), later made the holotype, has a slightly tapered glabella and the anterior margin of the frontal glabellar lobe appears more rounded in plan than that of the present example, though the latter is longitudinally compressed and imcomplete. The holotype also has pustulose ornamentation over all the glabella, whereas here it is strongly developed only on the occipital ring and 1p glabellar segment, though there are incipient tubercles on the fixigenae and the front of the glabella, which also shows traces of three pairs of glabellar furrows on the internal mould.

An unfigured pygidium, GSC 62187, found also at GSC locality 92267 since the present illustrations were prepared, is 10.5 mm (estimated) wide with a median length of 5.9 mm; there are six transversely straight axial rings, the first three well defined, the sixth only faint, followed by a small terminal piece. Ross (1958) described the paratype pygidium as having five clearly defined rings with the possibility (based on the distribution of granules) of a further four, though the latter would have to be very small, judging from his illustrations. Lochman (1966, p. 544, Pl. 62, fig. 12) described a pygidium (5 mm long) of *L.* (*L.*) *valmyense* from Montana that closely resembles the one from Wilcox Pass and has six axial rings, the last of them said to be faint. She pointed out that Ross's specimens also were very small (length of cranidium and pygidium = 4.5 mm and 2.75 mm respectively), and Ross originally suspected that his examples might be immature. Lochman's description noted the presence of two pits at each anterolateral corner of the glabella, a feature found in cranidia of *Leiostegium* (*Evansaspis*) *ceratopygoides* from Zone E at Wilcox Pass. The pygidium of *L.* (*L.*) *manitouense* (Walcott, 1925), from Zone D and redescribed by Berg and Ross (1959, p. 114, Pl. 21, figs. 10-13, 17, 24), is typical for the subgenus and differs but little from that of *L.* (*L.*) *valmyense*, though it appears to be a little longer and has a narrow axis with more (at least seven or eight) axial rings. The palpebral lobes of *L.* (*L.*) *manitouense* are noticeably smaller than those of *L.* (*L.*) *valmyense*.

Subgenus *Evansaspis* Kobayashi, 1955

Type species. Leiostegium (*Evansaspis*) *glabrum* Kobayashi, 1955 (this is a junior subjective synonym of *L.* (*E.*) *ceratopygoides* (Raymond, 1925 - see below).

Leiostegium (*Evansaspis*) *ceratopygoides* (Raymond, 1925)

Plate 21, figures 1-3, 5, 6, 8, 9, 11, 12;
Plate 22, figures 1, 2, 4, 6; Plate 42, figures 1, 5

Crepicephalus ceratopygoides Raymond, 1925, p. 53, Pl. 2, fig. 15.

Leiostegium formosa Hintze, 1953, p. 189, Pl. 8, figs. 8-10; Terrell, 1973, p. 79, Pl. 3, figs. 9, 10, 12, 13.

Leiostegium (*Evansaspis*) *glabrum* Kobayashi, 1955, p. 421, Pl. 2, figs. 11-17.

Lloydia (*Evansaspis*) *formosa* (Hintze). Lochman, 1965, p. 466.

Leiostegium ceratopygoides (Raymond). Aitken and Norford, 1967, p. 181, 183.

Lloydia (*Evansaspis*) *ceratopygoides* (Raymond). Dean, 1978, p. 6, 7.

Holotype. MCZ 1674 (Pl. 42, figs. 1, 5), a pygidium in dilapidated condition from the "Lowest Ordovician", east of Harrogate, British Columbia, collected by F.P. Shepard and described by Raymond (1925, p. 53). This horizon would nowadays be considered part of the McKay Group.

Occurrences. Most of the specimens found at Wilcox Pass are from the middle member of the Survey Peak Formation at the following GSC localities, in ascending order: 92252, 92253, 92255, 92256, 92257, 92258, 92260 and 92262. These range from 166.8 m to 194.7 m above the base of the middle member. The youngest examples are from GSC locality 92263, 9.5 m above the base of the upper massive member. All these occurrences are considered to fall within Zone E of the Utah sequence, the zone from which Hintze (1953, p. 189-190) described *Leiostegium formosa*; Hintze did not, in 1953, record the species from Zone F as stated by Berg and Ross (1959, p. 113).

Dimensions (in mm). (IM) = internal mould; (EM) = external mould; (estd.) = estimated.

Pygidium	GSC 62276	GSC 62280	GSC 62282	GSC 62283	GSC 62284
Overall breadth	23.4 (EM) (estd.)	20.8 (EM) (estd.)	6.9 (EM)	21.2 (EM)	4.6 (EM)
Median length (excluding half-ring)	-	10.7 (IM)	3.5 (EM)	10.9 (EM)	2.1 (EM)
Length of axis	-	8.7 (IM)	2.7 (EM)	8.4 (EM)	1.6 (EM)
Frontal breadth of axis	5	5.2	1.7	4.6	1.1
Distance between inner sides of spine bases	9 (EM)	-	2.5 (EM) (estd.)	7.1 (EM)	1.6 (EM)

Description and discussion. As detailed accounts of *L.* (*E.*) *ceratopygoides*, in one or other of its nomenclatorial guises, are readily available elsewhere, only relevant comments need be made here. The holotype pygidium, although in a poor state of preservation, shows the characteristic pair of posterolaterally directed border spines and the relatively narrow (tr.), well segmented axis; also visible is part of the almost uniformly narrow (sag.) doublure, the structure of which is closely matched by that shown in Plate 21, figures, 9, 12. The border spines are directed posterolaterally upward in relation to the plane of the pygidial margin, but presumably lay on or parallel to the substrate when the animal was at rest on the seafloor. Kobayashi (1955, p. 422), in separating *L.* (*E.*) *glabrum* from *L. formosa* Hintze, 1953, attributed great importance to the

ornamentation of the exoskeleton, which was said to be smooth in the former species and tuberculate in the latter, as implied by the respective specific names. The present photograph (Pl. 22, fig. 1) of the holotype of *L.* (*E.*) *glabrum* shows that it, too, has numerous tubercles on the axis and pleural fields (the lateral border is smooth), but the largest pygidia from Wilcox Pass have the whole pygidial surface smooth or almost so. The smallest available pygidia (for example, Pl. 22, figs. 2, 6) are subtriangular in outline and strongly ornamented with closely spaced tubercles, some of which are paired. Ontogeny was apparently accompanied by a diminution in the development of tubercles, an increase in the relative length of the pygidium, and an increase in relative size of the paired border spines, which are sited proportionately farther from the axis of the largest pygidia.

A distinctive feature of the species is the relatively narrow pygidial axis, which extends to the inner margin of the lateral border. The last named is poorly defined on the largest pygidia, but on small specimens is bounded by a distinct lateral border furrow that is continuous anterolaterally with a pair of deep, broad (exsag.) furrows corresponding to the pleural furrows of the first pygidial segment. The axial outline is slightly funnel-shaped, with a small "break" about midpoint, and the axis is well segmented with about six well defined transversely straight axial rings and a further two or three less apparent ones.

No topotype material for the species has been described, and evidence of the cranidium of *L.* (*E.*) *ceratopygoides* at Wilcox Pass is limited to a few fragments, for example Pl. 21, fig. 2, which shows closely spaced granules ornamenting the glabella and fixigena. A large, exfoliated left librigena (Pl. 21, fig. 8) matches specimens illustrated by both Hintze (1953, Pl. 8, fig. 8) and Terrell (1973, Pl. 3, fig. 9).

Family MISSISQUOIIDAE Hupé, 1953

Genus *Missisquoia* Shaw, 1951

Type species. ***Missisquoia typicalis*** Shaw, 1951.

Subjective synonyms. ***Macroculites*** Kobayashi (1955, p. 460), ***Rhamphopyge*** Kobayashi (1955, p. 472) (Dean, 1977). To these Ludvigsen (1982, p. 119) added ***Paranumia*** Hu (1973, p. 86) and ***Tangshanaspis*** Zhou and Zhang (1978, p. 15, 25). ***Lunacrania*** Kobayashi (1955, p. 472) was considered synonymous by Dean (1977, p. 2) and by Ludvigsen (1982, p. 11) but was regarded as a separate missisquoiid genus by Fortey (in Fortey, Landing and Skevington, 1982, p. 112) on the basis of its small, more anteriorly placed eyes and broader (exsag.) postocular fixigenae. Jell and Stait (1985, p. 41-43), in reviewing the Missisquoiidae, disagreed with Fortey's interpretation but speculated that both ***Missisquoia*** and ***Lunacrania*** may be synonyms of ***Parakoldinioidia*** Endo, 1937 (in Endo and Resser, 1937). The question cannot be resolved satisfactorily without further topotype material of the type species ***Lunacrania trisecta*** Kobayashi, 1955, but the criteria noted by Fortey apply also to ***Tangshanaspis zhaogezhaungensis*** Zhou and Zhang (1978, Pl. 1, fig. 22), placed by Ludvigsen (1982, p. 119) in synonymy with ***Missisquoia depressa*** Stitt (1971, p. 25).

Hu (1971, p. 108) first noted the resemblance of the widely recored ***Missisquoia*** to the less well known ***Parakoldinioidia***, misquoted by him as ***Parakoldinoides***. The type species, ***Parakoldinioidia typicalis*** Endo (in Endo and Resser, 1937, p. 329, Pl. 71 figs. 17-23), came from the Yenchou Formation of Manchoukuo; Endo cited the originals of his figures 17 and 18 as cotypes, and figures 19 to 22 as paratypes, but all are best regarded as syntypes. The pygidium assigned to the species by Endo (in Endo and Resser, 1937, Pl. 7, fig. 23) is very different from that of ***Missisquoia***, and Hu believed it to have been misidentified. A detailed redescription of ***Parakoldinioidia typicalis*** is still lacking, and for the present, ***Missisquois*** is retained as a separate genus. Meraspid cranidia of ***M. cyclochila*** Hu (1971, p. 108, Textfig. 51) and holaspid cranidia of ***M. depressa*** Stitt (1971, p. 25, Pl. 8, figs. 5, 6) show a distinct resemblance to the Leiostegiidae. Shergold (1975, p. 195) placed the Missisquoiidae in the Superfamily Leiostegiacea, a view with which I agree, and further discussion is provided by Jell and Stait (1985, p. 41). There is some disagreement on the identification of ***Missisquoia*** outside North America, and ***M. perpetis*** Zhou and Zhang (1984, p. 93) from northeastern China has been reassigned to ***Pseudokoldinoidia*** Endo, 1944 by Duan and others (1986, p. 41).

Missisquoia typicalis Shaw, 1951

Plate 13, figures 1-5, 7, 13

Missisquoia typicalis Shaw, 1951, p. 108, Pl. 23, figs. 1-10; Lochman-Balk in Moore, 1959, p. 510, Fig. 403; Winston and Nicholls, 1967, p. 88, Pl. 13, figs. 2, 5, 6, 10, 12, 15, 18. Dean, 1977, p. 4, Pl. 1, figs. 4, 5, 7, 9, 12, 15 (includes synonymy); Taylor and Halley, 1974, p. 22, Pl. 3, figs. 1-9; Fortey in Fortey, Landing and Skevington, 1982, p. 112, Pl. 2, fig. 4; Pl. 3, fig. 2.

Occurrences. Survey Peak Formation, basal silty member, GSC localities, in ascending order: 89269, 92223 and 89273, ranging from 17.2 m to 18 m above the base. Recorded questionably from GSC localities 92215, 89274, 92219 and 92225, at levels from 13.5 m to 19.2 m above the base of the same member.

Description and discussion. The species has been described on numerous occasions and little need be added here. Material from Wilcox Pass bears out Shaw's (1951, p. 109) comment that the pygidium "shows a notable change during ontogeny", with pygidia 2.8 mm or more in length having a terminal spine.

Missisquoia enigmatica (Kobayashi, 1955)

Plate 13, figures 6, 8, 10

Macroculites enigmaticus Kobayashi, 1955, p. 461, Pl. 6, fig. 14.

Missisquoia nasuta Winston and Nicholls, 1967, p. 89, Pl. 13, figs. 1, 3, 9.

Missisquoia enigmatica (Kobayashi). Dean, 1977, p. 4, Pl. 1, figs. 1-3, 6, 8. Includes synonymy.

Occurrences. Survey Peak Formation, basal silty member, 18 m above base, at GSC locality 89273. Questionably at GSC locality 92223, 17.7 m above base of member. The holotype was described from the McKay Group.

Description and discussion. In pygidia about 3 mm long (for example Pl. 13, figs. 8, 10) the axis may be of conspicuously humped appearance in lateral view, with segmentation of both axis and pleural regions less apparent behind the second or third segments.

Missisquoia sp.

Plate 13, figure 9

Occurrence. Survey Peak Formation, basal silty member, 17.1 m above base; GSC locality 92219.

Description and discussion. A single, small pygidium, about 2 mm long, has pleural regions composed of at least five and a half pairs of ribs that end in free points resembling those of *M. typicalis*. Each rib carries an interpleural furrow that is deepest outside the fulcrum, where the dorsal surface declines steeply to the concave border. The axis is more pointed and better segmented than that of *M. typicalis*, with seven, possibly eight, transversely straight axial rings, the last three very small, and a terminal piece of diminutive size. The longitudinal median third of the axis is marked by shallowing of the ring furrows and the development of low, paired tubercles. The latter feature, not yet described for *M. typicalis* and *M. enigmatica*, was one of those listed by Zhou and Zhang (1978, p. 25) as distinguishing *Tangshanaspis* from *Missisquoia*. *Missisquoia typicalis* was recorded questionably from the same locality at Wilcox Pass and the specimen may possibly represent an immature example of that species.

Family KAINELLIDAE Ulrich and Resser, 1930

The genera below have often been assigned to the Richardsonellidae Raymond, 1924, but the unsuitability of the latter has been discussed by Shergold (1975), Zhou and Zhang (1978) and Ludvigsen (1982), all of whose preferred usage of Kainellidae is followed here.

Genus *Kainella* Walcott, 1925

Type species. Hungaia billingsi Walcott, 1924.

Kainella billingsi (Walcott, 1924)

Plate 22, figures 3, 5, 7-13; Plate 23, figures 1-3, 5-13; Plate 42, figures 2, 3, 7, 8, 10, 12

Hungaia billingsi Walcott, 1924, p. 37, Fig. 7.

Kainella billingsi (Walcott). Walcott, 1925, p. 102, Pl. 22, figs. 1-7; Kobayashi, 1953, p. 43; Kobayashi, 1955, p. 413; Lochman, 1965, p. 481; Norford et al., 1970, p. 608, Pl. 5, figs. 31, 32.

Type material. The species was founded on five syntypes from the Chushina Formation at Extinguisher Tower (sometimes known, incorrectly, as Billings Butte), near Mount Robson, British Columbia. Aitken and Norford (1967, p. 157) considered the Chushina Formation to be inadequately defined and equivalent to at least the lower part of the Survey Peak Formation. All the type material is in the U.S. National Museum, Washington, D.C. and USNM 70334 (Pl. 42, figs. 8, 12) is chosen as lectotype. Two paralectotypes, USNM 70335 (Pl. 42, fig. 10) and USNM 70336 (Pl. 42, figs. 2, 3, 7) are now re-illustrated.

Occurrences. Survey Peak Formation, middle member, GSC localities, in ascending order: 92240, 92241, 92242, 92243, 92244, 92245 and 92246, extending from 60.6 m to 90.1 m above the base of the member. After an almost barren interval, fragmentary evidence of the species was found at GSC locality 94447, 143.5 m above the base of the member. Zone D, as postulated by Lochman (1965, p. 481) for the type material of *Kainella billingsi* near Mount Robson.

Dimensions (in mm). (IM) = internal mould; (EM) = external mould; (estd.) = estimated.

Cranidium	GSC 62296	GSC 62299	GSC 62302	GSC 62303	GSC 70334
Median projected length	2.8 (IM)	-	14 (IM)	12.8 (EM)	40 (IM)
Length of glabella and occipital ring	2.1 (IM)	9.3 (IM)	10.4 (IM)	7.8 (EM)	29 (IM)
Breadth of frontal area	3.5 (IM) (estd.)	17 (IM) (estd.)	19 (IM) (estd.)	12.7 (EM)	54 (IM.) (estd.)
Basal breadth of glabella	1.5 (IM)	6.6 (IM)	8 (estd.)	5.6 (estd.)	28 (IM)
Distance across palpebral lobes	2.9 (IM) (estd.)	9.5 (IM) (estd.)	10.5 (IM) (estd.)	7.6 (IM) (estd.)	-

Pygidium	GSC 62305	GSC 62308	GSC 62311	USNM 70336
Overall breadth	9 (EM)	6.2 (IM)	10 (EM) (estd.)	34 (IM) (estd.)
Median length, excluding half-ring	7 (EM) (estd.)	4.1 (IM)	7.2 (EM) (estd.)	30 (IM) (estd.)
Length of axis	5.5 (EM) (estd.)	3.3 (IM)	4.8 (EM)	21 (IM)
Frontal breadth of axis	4.2 (EM)	2.5 (IM)	4 (EM)	14 (IM)

Description and discussion. For convenience, all material of *Kainella* is discussed together at the end of the section.

Kainella flagricauda (White, 1874)

Plate 23, figure 4; Plate 42, figures 9, 11, 13

Dicellocephalus flagricaudus White, 1874, p. 12.

Dicellocephalus? flagricaudus White. White, 1877, p. 60-61, Pl. 3, fig. 8a, b.

Dicellocephalus inexpectans Walcott, 1884, p. 90, Pl. 1, fig. 10.

Kainella flagricauda (White). Walcott, 1925, p. 102; Kobayashi, 1953, p. 45, Pl. 3, fig. 5; Lochman, 1965, p. 480, Pl. 62, figs. 19-28.

Kainella inexpectans Walcott. Walcott, 1925, p. 102; Kobayashi, 1953, p. 44.

?*Kainella* sp. Ross, 1957, p. 500, Pl. 43, figs. 23, 24, 27-30.

Holotype. USNM 15452, an exfoliated pygidium, now refigured (Pl. 42, fig. 9), described as coming from "strata of the age of the Quebec group of Canada" at Schellbourne, Schell Creek Range, Nevada. Dimensions: overall breadth = 8.2 mm, median length = 5.5 mm, length of axis = 4.5 mm, frontal breadth of axis = 3.5 mm.

Occurrence. Survey Peak Formation, GSC locality 92245, 91 m above base of middle member.

Other material. Cranidium USNM 24564 (Pl. 42, figs. 11, 13), holotype of *Dicellocephalus inexpectans* (Walcott, 1884), considered by Lochman (1965, p. 480, 481) to be a junior subjective synonym of *K. flagricauda* (see discussion later). The specimen came from the "lower portion of Pogonip Group, east slope of ridge next east of Hamburg Ridge, Eureka district, Nevada". Dimensions: breadth (tr.) of frontal area = 8 mm, median length of cranidium = 5.4 mm, length of glabella and occipital ring = 4 mm, basal breadth of glabella = 3.5 mm.

Description and discussion. At its type locality *Kainella billingsi* is a very large species of the genus, and was founded on specimens from dark-grey limestone in the Chushina Formation. Material from Wilcox Pass represents smaller individuals and was collected from thin beds of tough, calcareous and dolomitic siltstone. A notable feature of the species is the relatively long, narrow glabella, the sides of which are slightly curved, abaxially concave. 1p lateral glabellar furrows are moderately deep, diverging anteriorly approximately at right angles toward, though not reaching, the axial furrows approximately opposite the mid-points of the palpebral lobes. The 2p furrows are shallower, in some cases almost effaced, and run subparallel to the 1p furrows, terminating inside the axial furrows opposite the front of the palpebral lobes. 3p glabellar furrows are sometimes visible as narrow (exs.) depressions, transverse in direction. The three pairs of lateral glabellar lobes so delimited and the frontal glabellar lobe are of similar length; all three pairs of lateral furrows end adaxially in-line to leave a median band that averages about one third the breadth of the glabella in large cranidia, and slightly more in the smallest. The frontal glabellar lobe is transversely subrectangular in plan and just inside the anterolateral angles of larger specimens a pair of strong caecal ridges diverges forward at approximately ninety degrees to traverse the long (sag.) preglabellar field and die out at the anterior border. Within the area bounded by the paired ridges, several other divergent ridges are apparent, becoming more weakly developed toward the axial line. A very small cranidium, GSC 62296 (Pl. 22, fig. 3), shows each of the two corresponding caecal ridges as part of a group of four that radiate apparently from a common point of origin; the outermost ridge is the largest and the rest become progressively less well developed adaxially.

A large, incomplete hypostoma and a smaller, complete specimen (Pl. 22, fig. 12; Pl. 23, figs. 2, 5, 9) have an outline that is subparallel-sided, becoming slightly broader just behind centre. A narrow, ridge-like lateral border is continuous with the low posterior border and grades into the small anterior wings, behind which are very shallow lateral notches. The median body is large, subrectangular in outline, a little broader (tr.) posteriorly, with well rounded corners, and is most convex forward of centre, where it is continuous with the anterior margin. An arcuate median furrow, moderately deep abaxially but scarcely defined at the axial line, divides the median body into two lobes, the anterior of which is much the larger (estimated 0.7 of the sagittal length) and dome-like in convexity; the posterior lobe is crescentic in outline and much lower.

The largest librigenae from Wilcox Pass closely resemble a figured paralectotype (Pl. 42, fig. 10) and one of them (Pl. 23, fig. 1) shows the lateral border continuous with the abaxial part of the slightly furrowed librigenal spine. The lateral border of one smaller example (Pl. 23, fig. 7) is narrow and rim-like. A well preserved specimen (Pl. 23, fig. 3) has a finely pitted surface (the pits are asymmetric in cross-section and deepen slightly toward the axis) and has a narrow caecal ridge that runs from just below the eye to the base of the librigenal spine; faint, radiating caecal ridges occur immediately in front.

Fragments of thoracic segment, for example Pl. 23, fig. 6, show that each pleura turned backward sharply to form a long, wide-based pleural spine carrying a narrow pleural furrow that dies out beyond the fulcrum after passing for some distance subparallel to the posterior margin.

The type material of *Kainella billingsi* includes a large pygidium (Pl. 42, fig. 3) in which the long, slim, gently tapered axis has six distinct axial rings followed by traces of a diminutive seventh and a small, triangular terminal piece that passes into a sharp, postaxial ridge. The ring furrows, except for the first, are sinuous in plan, convex posteriorly at the sagittal line where they become a little shallower. Specimens from Wilcox Pass exhibit some variation in outline and degree of taper of the axis.

The specimen figured in Pl. 23, figs. 12, 13 carries a small terminal piece and six axial rings, of which all, except the first, are delimited by more or less sinuous ring furrows. One pygidium (Pl. 23, figs. 8, 11) is included with some hesitation in *K. billingsi* as the axis is relatively short, strongly tapered, and only three axial rings are clearly visible. However, the development of ring furrows is slightly irregular and the pygidium, which occurs with other parts of the exoskeleton referred more confidently to *K. billingsi*, may represent an abnormal specimen.

The thoracic pleural furrows noted earlier have their analogues in the deep furrows that traverse the pleural fields of the pygidium. Although pairs of pleurae may in some cases appear to be separated by a single, deep furrow others (Pl. 23, figs. 12, 13; Pl. 42, fig. 3) show a bifurcation whereby the true pleural furrow runs a short distance along the free point close to the margin, while the almost indistinguishable interpleural furrow meets the junction of adjacent free point...

The surface of at least the glabella and posterior border is covered with close-spaced granules on certain large cranidia. Pitting of the librigenal surface was noted earlier. Coarse granules occur also on the terminal piece and post-axial ridge of the pygidium, though not on the remainder, where ornamentation is restricted to subparallel, anastomosing ridges on the upper surface of the free points. Similar ridges occur on the thoracic pleural spines and on the lateral border of the hypostoma. As is the case for most, possibly all, remopleuridacean trilobites, the occipital ring carries a median tubercle, though it may be less discernible on large cranidia.

Dicellocephalus? *flagricauda* White (1874, p. 12; 1877, p. 60, fig. 8, 8a) and *Dicellocephalus inexpectans* Walcott (1884, p. 90, Pl. 1, fig. 10) are clearly referable to *Kainella*, as was appreciated by Walcott (1925, p. 102), and both are in need of revision on the basis of topotype material. As noted earlier, the type pygidium of *D. flagricauda* came from Schellbourne, Nevada, while the type cranidium of *D. inexpectans* came from the Pogonip Group near Eureka, Nevada; both holotypes are refigured here for completeness. Lochman's (1966, p. 481) claim that the two are synonymous rested on her discovery of appropriate cranidia and pygidia associated in strata assigned to Zone D that form part of the subsurface Deadwood Formation in the Williston Basin, Montana. One cranidium figured by Lochman (1966, Pl. 62, fig. 22) closely resembles the holotype of *Dicellocephalus inexpectans* (Pl. 42, figs. 11, 13 of present paper); pygidia illustrated by Lochman (1966, Pl. 62, figs. 23, 26), though generally similar to the holotype of *D. flagricauda* (Pl. 42,

fig. 9), nevertheless exhibit a proportionately slimmer, slightly longer axis with at least five axial rings, delimited by ring furrows that in a few cases are flexed rather than transversely straight. Such minor differences may represent no more than intraspecific variation, as is found in the pygidium of *Kainella billingsi*; until such variation is demonstrated, Lochman's interpretation will be followed.

A small pygidium (Pl. 23, fig. 4) from GSC locality 92245 has four transversely straight axial rings and ring furrows, and closely matches the holotype of *Kainella flagricauda*, to which species it is here referred. Large specimens of *K. billingsi* were found at the same locality, but there was insufficient evidence to show whether all the material represents variation within a single species.

Kainella kindlei Kobayashi (1955, p. 413, Pl. 2, fig. 1) was founded on a single cranidium from the McKay Group at GSC locality 7977, which yielded, among others, *Leiostegium (Evansaspis) ceratopygoides*, *Paenebeltella convexa* and *Tesselacauda flabella*, an assemblage indicative of Zone E. The holotype is small (median length 5 mm) and may represent an immature individual; it differs from *Kainella billingsi* in that the sides of the glabella are abaxially convex in plan and the preglabellar field is proportionately shorter. Still smaller (?meraspid) cranidia of *K. billingsi* (Pl. 22, figs. 3, 5) from Wilcox Pass have the glabella more rounded frontally, though less tapered, than in large specimens, but retain the straight or slightly concave glabellar sides that are so typical of the species. Another feature of small examples of *K. billingsi* is the relatively large size of the palpebral lobes, which appear to have become proportionately smaller and less convex in plan during ontogeny.

Kainella, represented by *K. chinensis* Duan and An in Duan and others (1986, p. 67, Pl. 16, figs. 15-18), has been reported from northeast China. Details of the cranidia are difficult to distinguish, but they differ from typical *Kainella* in having shorter, less divergent anterior branches of the facial suture; the frontal glabellar lobe is narrow and rounded; and the glabellar outline widens posteriorly instead of being straight sided.

Genus *Apatokephaloides* Raymond, 1924

Type species. *Apatokephaloides clivosus* Raymond, 1924.

Apatokephaloides clivosus Raymond, 1924

Plate 24, figures 10-15

Apatokephaloides clivosus Raymond, 1924, p. 425, Pl. 13, fig. 13 only; Rasetti, 1963, p. 1010, Pl. 130, figs. 19, 20; Winston and Nicholls, 1967, p. 86, Pl. 11, fig. 11; Stitt, 1971, p. 45, Pl. 5, fig. 21.

Occurrences. Survey Peak Formation, basal silty member, GSC localities 92206 and 92207, 4.5 m and 4.7 m, respectively, above the base of the member. At both localities *A. clivosus* is associated with *Corbinia horatio* Walcott.

Description and discussion. The genus has been recorded only from the *Corbina apopsis* Zone of Winston and Nicholls (1967).

Genus *Apatokephalus* Brögger, 1896

Type species. *Trilobites serratus* Boeck, 1838.

Apatokephalus canadensis Kobayashi, 1953

Plate 24, figures 6, 9

Apatokephalus canadensis Kobayashi, 1953, p. 52, Pl. 3, figs. 1-4; Kobayashi, 1955, p. 414, Pl. 2, fig. 2; Lochman, 1965, p. 480.

Holotype. GSC 11926 (Pl. 24, fig. 9).

Paratype. GSC 11927 (Pl. 24, fig. 6).

Occurrences. Kobayashi's original description stated only that the type material had been collected by Evans (1933) from a locality "north of first stream east, north of Brisco Trail, British Columbia". The horizon was said later (Kobayashi, 1955) to be within the McKay Group.

Description and discussion. Although *Apatokephalus canadensis* has not yet been found at Wilcox Pass, the species is refigured here to facilitate comparison with other representatives of the genus. Distinctive features of the cranidium include: well developed ornamentation, comprising closely set, small granules, that extends on to the palpebral lobes; long (exs.) palpebral lobes; the right-angled lateral extremities of the glabella, marking a maximum breadth (tr.) attained only slightly behind centre of the glabella; long (tr.), sigmoidal 1p glabellar furrows and very short 3p furrows. The pygidium, with tubercles on the surface of the pleural regions, has a large, long axis that, though damaged, shows at least three axial rings. There are five pairs of pleural, the first four of which carry deeply impressed pleurae furrows, and all end in unornamented free points.

Lochman (1965, p. 467-468, 480, Pl. 62, figs. 29, 30) recorded *Apatokephalus* cf. *A. canadensis* from subsurface strata of the Williston Basin, Montana, that she assigned to Zone D of Ross (1949). Later she (Lochman, 1966, p. 545) stated that Kobayashi (1955) had identified the species from Zone G in the McKay Group of British Columbia. According to Kobayashi's (1955, p. 367, 414) account, *A. canadensis* formed part of his *Apatokephalus - Peltura* faunule and was associated at his locality 20 with *Asaphellus*? *canadensis* Kobayashi, *Kayseraspis*? *euclides* (Walcott) and *Peltura canadensis* Kobayashi. On the other hand, the original locality data (Kobayashi, 1953) correspond to what can only be interpreted as either locality 2 or locality 12 of the later publication (Kobayashi, 1955, p. 362). Both the last two localities were said to contain the *Kainella - Evansaspis* fauna (Kobayashi, 1955, p. 369) and would thus correspond to part of the middle member of the Survey Peak Formation, or Zones D and E.

Apatokephalus finalis (Walcott, 1884)

Plate 42, figures 4, 6, 14

Dicellocephalus finalis Walcott, 1884, p. 89, Pl. 12, fig. 12, 12a.

Apatokephalus finalis (Walcott). Lochman, 1965, p. 480, Pl. 62, figs. 31, 32.

Figured syntypes. A cranidium (Pl. 42, fig. 14; Walcott, 1884, Pl. 12, fig. 12) and a pygidium (Pl. 42, figs. 4, 6; Walcott, 1884, Pl. 12, fig. 12a). Both specimens are registered as U.S. National Museum 24563.

Occurrences. Walcott's specimens were said to come from the Pogonip Group "east of Hamburg Ridge, Eureka district, Nevada". The same area yielded the type material, refigured

elsewhere in this paper, of *Kainella inexpectans* (Walcott, 1884) and of *Clelandia*? [= *Desmetia*] *annectans* (Walcott, 1884). Although the species differ from those at Wilcox Pass, the genera correspond to elements in both the putty shale and middle members of the Survey Peak Formation. In Nevada, *A. finalis* was recorded, but not described, from Zone D (= *Leiostegium-Kainella* Zone) by Hintze (1953, p. 9). As noted by Lockman (1965, p. 480) the species possesses a distinct preglabellar field, though its development does not approach that seen in *Apatokephalus*? *longifrons* of the present paper.

Apatokephalus sp.

Plate 24, figures 3, 5, 8

Occurrences. All specimens are from the Outram Formation; GSC 62293 and GSC 62294 are from GSC locality 92270, 5 m above the base of the formation; GSC 62295 is from GSC locality 92283, 58.8 m above the base. Zone G (undivided).

Description and discussion. In two incomplete cranidia (Pl. 24, figs. 3, 5) the breadth of the glabella is almost equal to the length, and the breadth of the large glabellar tongue is about two thirds that of the glabella. Anterior border extends laterally almost in line with the palpebral lobes. At point of maximum glabellar breadth, the palpebral furrows turn sharply through almost a right angle.

A fragment of pygidium (Pl. 24, fig. 8) shows only the external mould of the ventral surface of the doublure, with traces of four pairs of pleural spines; the first three pairs are almost in line, but the fourth pair is shorter and smaller.

Apatokephalus? *longifrons* n. sp.

Plate 24, figures 1, 2, 4, 7

Diagnosis. *Apatokephalus*-like species distinguished by: long (sag.) preglabellar field, equal to one sixth of the glabellar length; a glabella with breadth slightly greater than length and almost straight, transverse anterior margin; three pairs of well developed glabellar furrows, those of the 3p pair straight, directed slightly forward adaxially from axial furrows at points opposite front of palpebral lobes; palpebral lobes large and wide. Immature cranidium shows pair of crescentic areas sited between palpebral furrows and shallow axial furrow. Surface of cranidium apparently smooth or with only faint traces of fine tubercles. Remainder of exoskeleton unknown.

Holotype. GSC 62291 (Pl. 24, figs. 1, 2, 4).

Paratype. GSC 62292 (Pl. 24, fig. 7).

Occurrences. Survey Peak Formation, GSC locality 92241, 62 m above the base of the middle member. Zone D. Questionable evidence of the species was found at GSC locality 92261 (Zone E), 8 m below the top of the middle member, and at GSC locality 92267 (Zone F), 74.5 m above the base of the upper massive member.

Description and discussion. *Apatokephalus*, although almost cosmopolitan in its geographic distribution, is a remarkably compact genus and there is little point in giving a long account of features common to most, if not all, species. Particularly noteworthy in *A.*? *longifrons* are: the long preglabellar field, which has no counterpart in any described species; the relatively long (tr.), straight 2p and 3p glabellar furrows; and the weak development, in an apparently immature cranidium, of crescentic areas situated opposite the 2p and, in part, 1p glabellar lobes, and bounded by the axial furrows and palpebral furrows. The last-named feature is similar to, though less well developed than, corresponding structures in *Menoparia* (see p. 36 of this paper), considered by Ross (1951a, p. 87) to be among the most diagnostic characters of that genus. Ross (1953, p. 636) speculated that *Menoparia* (from Zone G) may be a descendant of *Apatokephalus*; the crescentic areas of *A.*? *longifrons* (from Zone D) suggest that the latter species might qualify as an appropriate ancestral form.

Genus *Menoparia* Ross, 1951

Type species. *Menoparia genalunata* Ross, 1951.

Menoparia elegans n. sp.

Plate 25, figures 1-11

Diagnosis. Large *Menoparia* species in which: glabellar tongue expands forward in largest specimens; 1p glabellar furrows form broad (exs.), subelliptical depressions; anterolateral parts of occipital ring are depressed and form well defined occipital lobes; pair of narrow (tr.) crescentic areas is situated between palpebral furrows and clearly defined axial furrows. Strongly convex pygidium has subtriangular axis with two large axial rings and ill-defined terminal piece. Pleural regions become less convex abaxially, composed of four fused segments that end in unequal pairs of free points. Pleural furrows weaker from first to fourth; interpleural furrows faint. Surface of exoskeleton carries Bertillon pattern of low, thin ridges.

Holotype. Cranidium, GSC 62312 (Pl. 25, figs. 1-3, 7, 11).

Paratypes. GSC 62313 (Pl. 25, fig. 4), GSC 62314 (Pl. 25, fig. 5), GSC 62315 (Pl. 25, fig. 6), GSC 62316 (Pl. 25, figs. 8-10).

Occurrences. All the type material is from the Outram Formation at GSC locality 92276, 18.5 m above the base of the formation. The species was found also at GSC localities 92278 and 92279, 32 m and 35 m, respectively, above the base of the same formation. Zone G (undivided).

Dimensions (in mm).

	GSC 62312	GSC 62315
Median length of cranidium	10.6	2.9
Length of combined glabella and occipital ring	9.3	2.5
Maximum breadth of glabella	7.5	2
Distance across palpebral lobes	11	3.3
Distance across frontal portion of cranidium	10.7	2.6

Pygidium: GSC 62316; overall breadth = 9.1 mm estimated, median length, including fourth pleural spines = 6.7 mm, length of axis = 3.7 mm, frontal breadth of axis = 4 mm.

Description. The glabella is as broad as long, of low convexity posteriorly, becoming more convex frontally; the anterior third forms a tongue-like projection, moderately

declined frontally where it expands to attain a breadth approximately two thirds that of the glabella. The 1p glabellar furrows comprise a pair of subelliptical depressions that do not reach the axial furrows; the 2p glabellar furrows are deep, incised and straight, running inward and back from the axial furrows. Wide (tr.) palpebral lobes are semicircular in plan, their projected length (exs.) about two thirds that of the glabella; a subcrescentic area of fixigena is sited on either side of the glabella, bounded by the axial furrow and the palpebral furrow. Behind each palpebral lobe a diminutive strip of fixigena skirts the axial furrow and coalesces with a slim, pointed projection (formed by the adaxial portion of the posterior border), along which the posterior branch of the facial suture runs to meet the posterior cephalic margin. The large, almost uniformly broad (exs.) occipital ring has a very small median tubercle (Pl. 25, figs. 5, 11) sited immediately behind the narrow occipital furrow; a pair of subelliptical occipital lobes is developed in the depressed, anterolateral portions of the occipital ring. Immediately in front of the palpebral lobes the anterior branches of the facial suture are broadly splayed frontally until almost in line with the abaxial margins of the palpebral lobes, when they turn adaxially through more than a right angle and then cut the anterior margin. The frontal margin of the cranidium is rounded in plan and the broad (sag.) anterior border is separated from the glabella by a narrow (sag.), uniformly deep furrow that contains about sixteen or seventeen pits. The genal angles are produced to form long librigenal spines, each with a deep notch at its base. One well preserved librigena (Pl. 25, fig. 4) shows a pair of strong genal caeca diverging adaxially from the base of the librigenal spine.

A single large pygidium is composed of four fused segments, all of which turn strongly back abaxially and terminate in four pairs of free points that diminish in size from first to fourth. The first three pairs form curved spines, and each pleura is divided into subequal bands by pleural furrows that become shallower from first to third and do not attain the bases of the pleural spines; the fourth pair of spines is reduced to no more than a short, bifid projection, shorter than on third pair. The conspicuous axis carries two large, transversely straight axial rings, followed by an ill defined, short terminal piece; the last-named is scarcely distinguishable from the convex, steeply declined surface of the inner half of the pleural regions, which in turn passes gradually into the almost horizontal outer half. The surface of both cephalon and pygidium carries a conspicuous Bertillon pattern of narrow ridges that is seen to cross at least some of the cephalic furrows, for example the anterior border furrow, the palpebral furrows and the central portion of the 1p glabellar furrows (Pl. 25, figs. 2, 5, 11).

Discussion. The affinities of the new species clearly lie with *Menoparia genalunata* Ross (1951a, p. 88; 1951b, p. 579-583; 1953, p. 634), from both Zone G(1) and Zone G(2) in Utah, and *M. lunalata* Ross (1953, p. 635), from near the top of Zone G in Utah. The holotype cranidia of both *M. genalunata* and *M. lunalata* are smaller than that of *M. elegans*. The glabellar tongue of *M. elegans* expands forward much more strongly, the 1p glabellar furrows are notably larger, and the occipital lobes are more strongly developed, than in either *M. genalunata* or *M. lunalata*. The crescentic areas of *M. elegans* are less symmetrical and proportionately much narrower than in *M. lunalata*, though only slightly less so than in *M. genalunata*. In plan view the palpebral lobes of *M. lunalata* are much more laterally convex than in the new species, the posterior half of the glabellar outline is less expanded, and the anterior branches of the facial suture run almost transversely from the eyes. Judging from a later illustration by Ross (1953, Pl. 83, fig. 20) the posterior halves of the fixigenae of *M. genalunata* are probably longer (tr.) than those of *M. elegans*.

The pygidium of *M. elegans*, though generally similar to that of *M. genalunata*, is distinguished by its greater overall convexity, particularly of the inner half of the pleural regions (see Pl. 25, figs. 9, 10), and by the smaller terminal piece of the axis. The axial rings of *M. elegans*, though incompletely known, appear to be larger and the axial furrows transversely straighter. The pygidium of *M. lunalata* was said by Ross (1953, p. 636) to be indistinguishable from that of *M. genalunata*.

Family DIMEROPYGIDAE Hupé, 1953

Genus *Ischyrotoma* Raymond, 1925

Type species. Ischyrotoma twenhofeli Raymond, 1925.

Junior subjective synonym. Dimeropygiella Ross, 1951a, p. 123 (see Whittington, 1963, p. 47).

Ischyrotoma cf. *I. caudanodosa* (Ross, 1951)

Plate 28, figures 7, 9, 10, 13, 15-17

Occurrences. 0.2 m below the top of the Outram Formation, GSC locality 92313; and 0.7 m above the base of the Skoki Formation, GSC locality 92316. Zone J.

Dimensions (in mm). (IM) = internal mould; (EM) = external mould; (estd.) = estimated.

	GSC 62182	GSC 62333
Overall breadth of cephalon	3.9 (IM)	-
Median length of cranidium	2.9 (IM)	2.7 (IM)
Median length of combined glabella and occipital ring	2.3 (IM)	2.2 (IM)
Basal breadth of glabella	1.4 (IM)	1.4 (IM)
Distance across palpebral lobes	2.7 (IM) (estd.)	2.5 (IM) (estd.)

Description and discussion. The present material differs from cranidia described from Zone J in Utah as *Dimeropygiella caudanodosa* Ross (1951a, p. 124, Pl. 35, figs. 18, 22-28; see also Hintze, 1953, p. 154, Pl. 19, figs. 5, 10) in only minor details of the ornamenting tubercles, which are slightly smaller and less closely spaced in the Canadian specimens. *Ischyrotoma* [*Dimeropygiella*] *ovata* Hintze, 1953, p. 155, Pl. 19, figs. 1-4) and *I.* [*D.*] *blanda* (Hintze, 1953, p. 155, Pl. 19, figs. 6-8) (see also Young, 1973, p. 102, Pl. 2, figs. 1-7), both from Zone H of western Utah, are noticeably less coarsely ornamented than *I. caudanodosa*, and in the case of *I. blanda* the anterior border and glabella are separated by a relatively wide (sag.) preglabellar field. Cranidia of *I. anataphra* Fortey (1979, p. 104, Pl. 36, figs. 1-3, 5, 6, 8, 10-12), from Zone H in western Newfoundland, have slightly smaller tubercles of more uniform size, the anterior border projects less far forward, the preglabellar field is continuous with only a trace of a median depression, and the eyes are set farther forward.

Ischyrotoma cf. *I. eos* (Kobayashi, 1955)

Plate 28, figures 1-3, 5, 6

Occurrences. Middle member of the Survey Peak Formation, GSC localities 92252, 92253, and 92256, ranging from 166.8 m to 171.3 m above the base of the member. Zone E.

Dimensions. (IM) = internal mould; (EM) = external mould; (estd.) = estimated. Pygidium, GSC 62335. Overall breadth = 10.7 mm (estd.) (EM), median length = 5.7 mm (estd.) (EM), length of axis = 3.8 mm (IM), frontal breadth of axis = 3.2 mm (IM).

Description and discussion. The holotype, GSC 12712, of *Dimeropygiella eos* Kobayashi (1955, p. 456, Pl. 6, fig. 10), now refigured (Pl. 15, figs. 3, 6), came from GSC locality 8064 in the McKay Group of British Columbia. Although indifferently preserved, the pygidia from Wilcox Pass resemble the holotype in all essentials except that they consistently exhibit three axial rings instead of four. As the specimens are smaller than the holotype, this character may not be significant. An unassigned pygidium from Zone F in the Garden City Formation of Utah, illustrated but not described by Ross (1951a, Pl. 17, figs. 23, 28, 29), has slightly coarser tuberculation than *I. eos*, but otherwise appears indistinguishable.

Although the specimens noted above have a generally hystricurid aspect, all show the conspicuously bilobed terminal piece of the pygidial axis, a feature to which Kobayashi (1955, p. 457) drew attention. The same structure is not clearly visible in Whittington's (1963, Pl. 7, figs. 10 11) illustrations of *I. twenhofeli* Raymond, 1925, the type species, but is clearly shown by the pygidium of *I. caudanodosa* (Ross, 1951a, Pl. 35, figs. 25, 26), which differs from that of *I. eos* in having five axial rings and five and a half pairs of ribs.

Family PTYCHASPIDIDAE Raymond, 1925

Subfamily EUREKIINAE Hupé, 1953

Genus *Corbinia* Walcott, 1924

Type species. Corbinia horatio Walcott, 1924

Corbinia horatio Walcott, 1924

Plate 11, figures 8, 10-15; Plate 12, figures 1-12

Corbinia horatio Walcott, 1924, p. 55, Pl. 10, fig. 5; Walcott, 1925, p. 81, Pl. 16, figs. 19-22.

Corbinia valida Walcott, 1925, p. 82, Pl. 16, fig. 18.

?*Corbinia apopsis.* Westrop, Landing and Ludvigsen, 1981, p. 47.

Type material. Walcott's material of *C. horatio* came from what was then termed Mons Formation, now obsolete and considered synonymous with part of the Survey Peak Formation (Aitken and Norford, 1967, p. 155), on the north side of Clearwater Canyon, about 33.8 km (21 miles) north of Lake Louise station, Alberta. Three of the syntypes are now re-illustrated; USNM 70246, a left librigena (Pl. 12, fig. 8); and a pygidium and cranidium (Pl. 12, figs. 9, 11), together numbered USNM 70248. The holotype cranidium (USNM 70244; see this paper, Pl. 12, fig. 6) of *Corbinia valida* Walcott, 1925 came from the same locality and horizon as *C. horatio*; the two are considered here as synonymous, and apparent differences are probably due to slight crushing of the glabella of *C. valida*.

Occurrences. Survey Peak Formation, lower part of basal silty member. GSC localities, in ascending order: 92206, 92207, 92208, 92209, and 92210; these range from 4.5 m to 5.9 m above the base of the member. *Saukia* Zone, *Corbinia apopsis* Subzone.

Description and discussion. Corbinia apopsis Winston and Nicholls (1967, p. 86, Pl. 11, figs. 13, 14, 17, 22), eponymous species of the highest subzone of the *Saukia* Zone in Texas, differs, according to its authors, from *Corbinia horatio* and *C. valida* "in having larger palpebral lobes, narrower border, and more parallel sided posterior limbs". From their description, the pygidium of *C. apopsis* has the first two pairs of pleural furrows deeply impressed only adaxially, while interpleural furrows are developed abaxially. Cephalic differences between *C. apopsis* and *C. horatio* appear to be very small. Some of the cranidia of *C. horatio* from Wilcox Pass now illustrated (Pl. 11, figs. 10, 14) show a very narrow (sag.) preglabellar field, but in others (Pl. 11, fig. 12) the structure is absent. From the pygidia of *C. horatio* it appears that the length becomes proportionately greater during ontogeny (compare Pl. 12, figs. 10, 12 with Pl. 11, fig. 13 and Pl. 12, fig. 2). Only two pairs of pleural furrows are developed, the second pair much less so than the first, while traces of interpleural furrows are scarcely visible. The pygidium may prove to be more reliable for distinguishing between *C. horatio* and *C. apopsis*, as the single example of the latter illustrated by Winston and Nicholls (1967, Pl. 11, fig. 17) appears to carry at least two distinct pairs of interpleural furrows and perhaps three pairs of pleural furrows.

Bayfieldia ulrichi Rasetti (1945, p. 465, Pl. 60, figs. 17-19), from the Lévis Conglomerate of Quebec, was assigned to *Corbinia* by Winston and Nicholls (1967, p. 86). The strongly granulose holotype cranidium of *C. ulrichi* is quite distinct from that of both *C. horatio* and *C. apopsis*, but the paratype pygidium may particularly be compared with Pl. 12, fig. 12 of the present paper, though the pleural fields of *C. ulrichi* appear to be proportionately smaller. Trilobites associated with *C. ulrichi* at Lévis include *Apatokephaloides*, a genus found with *C. horatio* at Wilcox Pass. Winston and Nicholls (1967, p. 86) considered *Bayfieldia* sp. of Rasetti (1959, p. 388, Pl. 55, figs. 20-23) from the Grove Limestone of Maryland to be synonymous with *C. apopsis*, but the material is incompletely preserved.

Family ASAPHIDAE Burmeister, 1843

Subfamily ASAPHINAE Burmeister, 1843

Genus *Aulacoparia* Hintze and Jaanusson, 1956

Type species. Asaphellus? *venta* Hintze, 1953.

Subgenus *Aulacoparia* (*Aulacoparia*)
Hintze and Jaanusson, 1956

Aulacoparia (*Aulacoparia*) *sculpta* n. sp.

Plate 30, figures 1-12; Plate 31, figures 1-6, 9

Diagnosis. Species of *A.* (*Aulacoparia*) with convex frontal area that is continuous with lateral border of fixigenae. Pygidium broader than long, subelliptical in plan, with broad

lateral border defined by shallow border furrow; most of pleural regions ornamented by anastomosing, narrow ridges subparallel to margin. Anterior half-ribs clearly defined, followed by traces of further two or three pairs of pleural and interpleural furrows; four axial rings present. Posterior margin of pygidium has deep, median notch that extends close to small, bilobed terminal piece of axis.

Holotype. GSC 62350 (Pl. 30, figs. 4, 5, 7).

Paratypes. GSC 62351 (Pl. 30, figs. 1-3), GSC 62352 (Pl. 30, figs. 6, 11), GSC 62353 (Pl. 30, fig. 9), GSC 62354 (Pl. 30, fig. 8), GSC 62355 (Pl. 30, fig. 10), GSC 62356 (Pl. 30, fig. 12), GSC 62357 (Pl. 31, fig. 1), GSC 62358 (Pl. 31, fig. 2), GSC 62359 (Pl. 31, fig. 3), GSC 62360 (Pl. 31, fig. 4), GSC 62361 (Pl. 31, fig. 5), GSC 62362 (Pl. 31, fig. 6), GSC 62363 (Pl. 31, fig. 9).

Occurrences. Outram Formation, Wilcox Pass. GSC localities include the following, in ascending order: 92270, 92272, 92273, 92274, 92275, 92276, 92277, 92278, 92279, 92280, 92281, 92282, 92283 and 92284. These range from 5.2 m to 60 m above the base of the formation. Zone G (undivided).

Dimensions of holotype. Overall breadth of pygidium = 10.8 mm (estimated), median length (excluding articulating half-ring) = 5.3 mm, frontal breadth of axis = 3.5 mm, length of axis = 4 mm.

Description and discussion. The new species closely resembles *A. (A.) venta* (Hintze, 1953, p. 134, Pl. 16, figs. 6-11), from Zone G(2) in Utah, but its cranidium differs from Hintze's (1953, Pl. 16, fig. 6a-c) holotype as follows: the anterior branches of the facial suture are more divergent frontally, so that the maximum breadth of the frontal area is proportionately greater (1.6 to 1.8 times the breadth of the frontal glabellar lobe, compared with 1.4); the eyes are set behind centre with reference to the glabella, whereas those of *A. (A.) venta* are opposite its centre; the occipital ring ends in a pair of occipital lobes that are distinct (Pl. 30, figs. 9, 12), though smaller than corresponding structures in *A. (A.) venta*.

The pygidium of the new species is particularly diagnostic and one is chosen as holotype. Almost semicircular in outline, breadth approximately twice the length (excluding the articulating half-ring), it is strongly arched both transversely and longitudinally (Pl. 30, figs. 4, 5). A conspicuous median notch indents the posterior margin and almost reaches the terminal piece of the axis; the notch is V-shaped in the largest pygidium (Pl. 30, fig. 4) but narrow, almost parallel sided in small specimens (Pl. 31, figs. 5, 6). The axis, well defined by incised axial furrows, stands well above the pleural fields and its outline is slightly funnel-shaped, with a break in continuity behind the anterior three-fifths, which contain three, transversely straight axial rings. The remaining two fifths of the axis are parallel sided, with only traces of a fourth axial ring, and end in a truncated terminal piece that shows evidence of bilobation in larger examples (Pl. 30, figs. 4, 7). A shallow but distinct border furrow delimits the slightly convex border, which is broadest (exsag.) laterally and narrows slightly toward the median notch and the tip of the axis. The pleural fields are slightly furrowed, particularly in larger pygidia, and two or three pairs of pleural furrows are generally present, though traces of a fourth have been detected; corresponding interpleural furrows are still shallower. The pygidium of *A. (A.) venta* is notably more triangular in outline with shallower first pleural furrows and border furrow, and the median notch is both shallower and more obtuse. In both species the surface is ornamented with a Bertillon pattern of closely grouped, fine ridges that is particularly conspicuous on the pleural fields and anterior half-ribs but weaker on the lateral border.

An incomplete cranidium from Zone G(1) of Utah noted by Ross (1951a, p. 103, Pl. 27, figs. 6, 7, 11) as *"Xenostegium" taurus* (Walcott) is a typical *A. (Aulacoparia)* and closely resembles the new species, though it is inadequate for detailed comparison. Another cranidium from Zone G(2) of Utah, assigned tentatively to *Macropyge gladiator* by Ross (1951a, Pl. 27, figs. 8-10), also belongs to *A. (Aulacoparia)* but the less divergent anterior branches of the facial suture and the more anteriorly placed eyes are closer to *A. (A.) venta* than to the new species. *Xenostegium taurus*, described by Walcott (1925, p. 128, Pl. 24, figs. 1, 2) from the Chushina Formation of the Robson Peak district, British Columbia, is not an *Aulacoparia*, though the inadequately known *Xenostegium? eudocia* Walcott (1925, p. 126, Pl. 24, fig. 12), from the St. Charles Formation of Cache County, Utah may be. *Xenostegium taurus* was made the type species of *Kobayashia* (Harrington, 1938) and is discussed below.

Material from the Goldwyer Formation of the Canning Basin, Western Australia described by Legg (1976, p. 9, Pl. 2, fig. 12; Pl. 3, figs. 8, 10, 11) as *?Aulacoparia* sp. probably does not belong to that genus. One cranidium (Legg, 1976, Pl. 2, fig. 12) has large, distinct 1p glabellar lobes, bounded by 1p furrows that are deep at the axial furrows and become shallower toward the occipital furrow, which they attain. Another cranidium (Legg, 1976, Pl. 3, fig. 8) also has fairly well defined 1p lobes and the width of the glabella is considerably greater across the frontal glabellar lobe than across the 1p lobes.

Subfamily ISOTELINAE Angelin, 1851

Genus *Kobayashia* Harrington, 1938

Type species. *Xenostegium taurus* Walcott, 1925.

Kobayashia cf. *K. douglasensis* (Walcott, 1925)

Plate 40, figures 5, 9

Occurrence. Outram Formation, GSC locality 92276; the age is Zone G (undivided).

Description and discussion. A single incomplete, but distinctive pygidium, breadth about twice the length (estimated), has a median length of about 14 mm, excluding the articulating half ring and the small terminal spine. The last-named forms a short, slim, thorn-like projection from the posterior margin and also represents an extension of a very low ridge that traverses the broad (sag.), almost flat pygidial border from the blunt tip of the straight-sided, gently tapered axis. Six large, uniformly wide (sag.) axial rings occupy the anterior 0.7 (estimated) of the axis, separated by distinct ring furrows that are slightly convex forward and deepen toward the broad, deep axial furrows. The remainder of the axis comprises three small, barely discernible rings and a small terminal piece. There is a faint suggestion of a median ridge on at least the rearmost part of the axis. The incomplete, plump pleural fields curve down steeply to the almost flat border; there is almost no trace of segmentation in addition to the pleural furrows defining the anterior half ribs.

Xenostegium douglasensis Walcott (1925, p. 125, Pl. 24, figs. 22, 23) was founded on a cranidium and pygidium from the Mons Formation at Douglas Lake Canyon Valley, Sawback Range, Alberta. It is one of several species assigned to *Kobayashia* by Harrington (1938, p. 223, 224), according to whom the genus has a triangular pygidium characterized by an axis wider and better segmented than that of

Xenostegium, and by feeble segmentation visible only on the anterior part. The partly exfoliated syntype pygidium has an axis, with straight sides and ring furrows, similar to that of the present specimen; its pleural fields are apparently unfurrowed, except for the pleural furrows defining the anterior half-ribs, and the distinct border is crossed by a small terminal spine. No further assessment is possible, and during the present collecting no cranidium was found that might be compared with the other syntype.

An incomplete pygidium from the McKay Group in British Columbia, one of the paratypes of *Kobayashia lanceolata* Kobayashi (1955, p. 441, Pl. 4, fig. 3) generally resembles the present specimen but the axis is narrower and was said to have only four or five rings. *Kobayashia lanceolata* was recorded from two localities, one of which contained *Protopresbynileus*? aff. *P. willdeni* (Hintze, 1953), a G2 species in Utah. It is unlikely that the pygidium from the other locality referred questionably to *Bellefontia* by Kobayashi (1955, p. 367, Pl. 5, fig. 5) belongs to that genus.

Genus *Isoteloides* Raymond, 1910

Type species. *Asaphus canalis* Whitfield, 1886 (see discussion in Fortey, 1979, p. 69).

Isoteloides saxosimontis n. sp.

Plate 31, figures 7, 8, 10-15; Plate 32, figures 1-9

Diagnosis. *Isoteloides* species with median length of cranidium 0.75 to 0.8 of maximum breadth. Anterior branches of facial suture diverge forward at 40 to 45 degrees to middle of broad (sag.) anterior border and then converge at about 120 degrees, producing sharply pointed front to cranidium. Palpebral lobes set just in front of transverse line through centre of glabella (excluding occipital ring). Median tubercle immediately in front of medially shallow occipital furrow appears large and distinct on internal moulds and is often, though not invariably, visible on external surface. Median glabellar ridge in front of median tubercle; four pairs of lateral glabellar lobes weakly developed. Narrow librigenae end in long, slim librigenal spines. Lateral and posterior border furrows die out toward genal angles. Pygidium subsemielliptical, its median length about 0.7 of maximum breadth. Small, well defined border slightly narrower anterolaterally. Axis well defined on internal moulds, but less so on exterior of test; frontal breadth is almost 0.3 that of pygidium. Up to about twelve straight axial rings and tiny terminal piece seen on internal moulds. Pleural fields carry about eight weakly defined pairs of ribs.

Holotype. GSC 62367 (Pl. 31, figs. 8, 12).

Paratypes. GSC 62364 (Pl. 31, fig. 7), GSC 62365 (Pl. 31, fig. 10), GSC 62366 (Pl. 31, fig. 13), GSC 62368 (Pl. 31, figs. 11, 14, 15), GSC 62369 (Pl. 32, figs. 1, 2), GSC 62370 (Pl. 32, fig. 4), GSC 62371 (Pl. 32, fig. 8), GSC 62372 (Pl. 32, fig. 3), GSC 62373 (Pl. 32, fig. 6), GSC 62374 (Pl. 32, fig. 5), GSC 62375 (Pl. 32, figs. 7, 9).

Occurrences. Outram Formation, in ascending order: GSC localities 92318, 92297, 92300, 92305, 92309, 92321, 92310 and 92322; these range through approximately the highest 51 m of the formation. Skoki Formation, 0.7 m above its base: GSC locality 92316. All in Zone J.

Questionable evidence of *Isoteloides*, though not the new species, was found in the Outram Formation at GSC localities 92273, 92275, 92276 and 92278, from 12 m to 32 m above the base. Zone G.

Dimensions. (IM) = internal mould; (EM) = external mould.

Cranidium, GSC 62367: median length = 15 mm (IM); length of glabella and occipital ring = 11.7 mm (IM); maximum breadth of frontal area = 11 mm (IM); distance across palpebral lobes = 11.7 mm (IM); breadth of glabella between palpebral lobes = about 7 mm (IM).

Pygidium, GSC 62373: maximum breadth = 11.7 mm (EM); median length (excluding half ring) = 8.3 mm (IM); frontal breadth of axis = 3.5 mm (IM); length of axis (excluding half ring) = 6 mm (IM).

Description and discussion. The new species resembles in many respects *Isoteloides*? *polaris* Poulsen (1927, p. 295, Pl. 19, figs. 10-14; Pl. 20, figs. 1, 2; see also Poulsen, 1946, p. 327, Pl. 23, fig. 1), described first from the Nunatami Formation of northwest Greenland and reported subsequently, as *I. polaris*, from Zone J in Utah by Hintze (1953, p. 171, Pl. 17, figs. 9-15). The cranidium of *I. polaris* has smaller eyes, and the anterior branches of the facial suture are less divergent forward in Poulsen's 1927 illustrations before converging to meet at a more obtuse angle at the front of the shorter anterior border and furrow. No glabellar lobes or median ridge and tubercle are visible in Poulsen's figures, but lobes and tubercle were noted by Hintze (1953, p. 171). The pygidium of *I. polaris* is only marginally shorter than that of *I. saxosimontis*, but the outline is more broadly rounded, the border widens anterolaterally, and the facets are directed more strongly backward; no segmentation is visible in Poulsen's illustrations, though it is weakly indicated on silicified material from Utah figured by Hintze (1953, Pl. 17, figs. 13a, 15). *Isoteloides flexus* Hintze (1953, p. 172), from Zone I, differs from the new species in having a wider frontal area, with the anterior branches of the facial suture meeting at a more obtuse angle, and the pygidial outline is more broadly rounded.

Material of *Isoteloides* from Zone H in western Newfoundland was assigned to *I. peri* Fortey (1979, p. 69, Pl. 23, figs. 1-8) and *I. latimarginatus* Fortey (1979, p. 72, Pl. 24, figs. 1-9). In both, the anterior branches of the facial suture are longer than those of *I. saxosimontis* and meet at a more obtuse angle, and the pygidial border is conspicuously wider. The librigena of *I. latimarginatus*, though more comparable with that of the Alberta species, is wider and the eye slightly larger. That of *I. peri* is notably wider, with more convex lateral margin, and the librigenal spine is larger.

Genus *Lachnostoma* Ross, 1951

Type species. *Lachnostoma latucelsum* Ross, 1951.

Lachnostoma latucelsum Ross, 1951

Plate 32, figures 10-15; Plate 33, figures 1-16

Lachnostoma latucelsum Ross, 1951a, p. 95, Pl. 21, figs. 13-25; Pl. 22, figs. 3, 6-8; Pl. 23, figs. 5, 6; Hintze, 1953, p. 187, Pl. 18, figs. 4-16.

Occurrences. Outram Formation, 149.5 m to 263.6 m above its base. GSC localities, in ascending order: 92286, 92287, 92288, 92289, 92292, 92293, 92295, 92318, 92296, 92297 and 92298 (same level), 92299 and 92300 (same level), 92301, 92302, 92303, 92305, 92319, 92309, 92321, 92310, 92322 and 92312. Zone J.

Description and discussion. *Lachnostoma latucelsum* was said by Hintze (1953, p. 187) to be one of the most abundant trilobites in the Wahwah Formation of the Pogonip Group in Utah, where "It ranges through the J Zone without apparent change". At Wilcox Pass even fragmentary cranidia are generally easily recognized, particularly distinctive features being the posteriorly located eyes, the strongly divergent anterior branches of the facial suture, and the almost clavate glabellar outline with well rounded frontal lobe. The anterior area has a breadth approximately 0.8 of the median length of the cranidium, and a pair of ill defined eye ridges may be visible, directed posterolaterally from the axial furrows just in front of the widest part of the glabella.

Three cranidia figured by Ross (1951a, Pl. 21, figs. 16, 22, 23) have the glabella moderately to well defined, but in the largest example shown by Hintze (1953, Pl. 18, fig. 9) it is less distinct than in smaller ones. In cranidia from Wilcox Pass the glabella is always clearly defined, especially laterally. Ross's photographs show clearly the median glabellar tubercle, sited just in front of the occipital furrow and level with the posterior ends of the palpebral lobes; the structure is scarcely visible in Hintze's illustrations, but is often strongly developed in the Canadian specimens, which may also show traces of a median ridge in front of it (for example, Pl. 32, fig. 13). One small cranidium, 3.8 mm long, from Wilcox Pass (Pl. 33, fig. 8) shows also a distinct preglabellar median ridge crossing the anterior border furrow, as in Ross (1951a, Pl. 21, fig. 16). The holotype of the species was a hypostoma but none was found during the present collecting.

Pygidia from Wilcox Pass match those from Utah and generally, though not invariably, the internal mould shows segmentation more clearly than the external surface (for example, Pl. 33, figs. 3, 5, 14). Eleven, or even twelve, straight axial rings may be visible, separated by ring furrows that shallow medially, where a weak median ridge may be present (Pl. 33, figs. 7, 14); the terminal piece is diminutive. The strongly convex pleural fields are well differentiated from the conspicuous, smooth border and up to at least six pairs of ribs have been detected, the latter divided into subequal, often ridge-like anterior and posterior bands by shallow interpleural furrows.

Genus *Presbynileus* Hintze, 1954

Type species. *Paranileus ibexensis* Hintze, 1953.

Objective synonym. *Paranileus* Hintze, 1953 *non* Kobayashi, 1951.

Subgenus *Presbynileus* Hintze, 1954

Presbynileus (*Presbynileus*) *latifrons* n. sp.

Plate 34, figures 1-4, 6, 7, 9-13;
Plate 35, figures 1-11

Diagnosis. *Presbynileus* (*Presbynileus*) species with steeply declined frontal glabellar lobe that is short (projected length = about 0.25 breadth), its outline transversely truncated anteriorly, bounded by strongly divergent anterior branches of the facial suture. Posterior half of glabella relatively narrow (= 0.5 of projected sagittal length) and parallel-sided, defined by deep axial furrows on internal mould. Eyes large, long (approximately 0.33 of projected length of cranidium), and stand high above glabella; palpebral lobes almost horizontal. Posterior halves of fixigenae narrow (exsag.) and posterior branches of facial suture meet posterior cephalic margin at acute angle (about 60°). Median tubercle sited well forward of occipital furrow is scarcely visible externally but clearly defined on internal mould, together with low median ridge and traces of three or four pairs of lateral glabellar lobes.

Pygidium subelliptical, almost twice as wide as long, its external surface almost smooth. Front of axis narrow, equal to 0.3 of pygidial breadth; at least six, possibly eight, axial rings visible on internal mould. Pleural regions have strongly defined pair of anterior half-ribs, but are otherwise almost smooth, even on internal mould. Panderian protuberances present on cephalic doublure in front of genal angles, and on pygidial doublure immediately in front of posterior margin.

Holotype. GSC 62393 (Pl. 34, figs. 6, 9).

Paratypes. GSC 62394 (Pl. 34, fig. 1), GSC 62395 (Pl. 34, fig. 2), GSC 62396 (Pl. 34, fig. 3), GSC 62397 (Pl. 34, fig. 4), GSC 62399 (Pl. 34, fig. 7), GSC 62400 (Pl. 34, fig. 10), GSC 62401 (Pl. 34, figs. 11, 12), GSC 62402 (Pl. 34, fig. 13), GSC 62403 (Pl. 35, figs. 1, 4), GSC 62404 (Pl. 35, fig. 5), GSC 62405 (Pl. 35, fig. 7), GSC 62406 (Pl. 35, figs. 2, 3, 6), GSC 62407 (Pl. 35, fig. 8), GSC 62408 (Pl. 35, fig. 9), GSC 62409 (Pl. 35, fig. 10), GSC 62410 (Pl. 35, fig. 11).

Occurrences. Outram Formation, topmost 133 m. GSC localities, in ascending order: 92285, 92291, 92292, 92293, 92294, 92295, 92318, 92297 and 92298 (same level), 92300, 92301, 92302, 92303, 92304 and 92319 (same level), 92308 and 92314. Skoki Formation, 0.7 m above its base; GSC locality 92316. Most occurrences are in Zone J, but the lowest 17 m are in strata tentatively assigned to Zone I. Species is recorded only questionably from GSC localities 92271, 92273, 92276 and 92281, all in Zone G (see Fig. 4).

Dimensions. Holotype cranidium: median projected length = 14.5 mm; basal breadth = 20.5 mm; breadth (tr.) of frontal glabellar lobe = 17 mm; length (exsag.) of palpebral lobes = 4.5 mm; distance across palpebral lobes = 16 mm. Paratype pygidium, GSC 62404; overall breadth = 35 mm; median length = 19 mm; frontal breadth of axis = 11 mm.

Description and discussion. Described species of *P.* (*Presbynileus*) differ in relatively minor respects, and diagnosis of the new form is intentionally long so as to facilitate comparison. *Presbynileus* (*P.*) *latifrons* is characterized particularly by the short, wide, steeply declined frontal glabellar lobe, whose truncated anterior margin contrasts with the rounded outline seen in *P.* (*P.*) *utahensis* (Hintze, 1953, p. 200, Pl. 13, figs. 1-4; Zone J) and *P.* (*P.*) *ibexensis* (Hintze, 1953, p. 199, Pl. 12, figs. 6-12; Zone I). The cranidium of *P.* (*P.*) *elongatus* (Hintze, 1953, p. 199, Pl. 12, figs. 2-5; Zone H) was not illustrated and the species was separated from the other two mainly on the basis of the pygidial shape and the presence of a small notch on the inner margin of the librigenal doublure near the genal angle. The large size and length of the eyes in the new species result in relatively slim (exsag.) posterior halves of the fixigenae, with the facial suture meeting the posterior cephalic margin at a more acute angle than in other forms. The frontal glabellar lobe sometimes (Pl. 34, figs. 2, 6) carries a coarse Bertillon pattern of ridges that dies out posteriorly. The ventral surface of both cephalic and pygidial doublures has well developed terrace lines subparallel to the margin. A right librigena (Pl. 34, figs. 11, 12) shows, in addition to the strongly convex visual surface, a large panderian protuberance just inside the lateral margin in front of the genal angle; a similar structure in *P.* (*P.*) *elongatus* (Hintze, 1953, Pl. 12, fig. 5b) has a panderian opening not seen here. The wide pygidial doublure of the new

species has a large median notch beneath the hindmost third of the axis; between the notch and the posterior margin is a large, wide (tr.) panderian protuberance (Pl. 34, fig. 10; Pl. 35, figs. 1, 4, 9, 11) followed apparently by an opening. All these structures are much less well developed in other species of the subgenus.

A single, incomplete cranidium (GSC 62398; Pl. 34, figs. 5, 8), from Zone J at GSC locality 92320, 243.3 m above the base of the Outram Formation, is referred to *P.* (*Presbynileus*) sp. It differs from *P.* (*P.*) *latifrons* in having a less strongly declined frontal glabellar lobe and a more rounded anterior margin that projects relatively farther forward. In these respects the specimen may be compared to *P.* (*P.*) *ibexensis* (Hintze, 1953, Pl. 12, fig. 9c), from Zone I in Utah, but the material is insufficient for specific determination.

Genus *Ptyocephalus* Whittington, 1948

Type species. *Ptyocephalus vigilans* Whittington, 1948.

Subjective synonym. *Kirkella* Kobayashi, 1942 *non* Gunnell, 1933.

Ptyocephalus declevitus (Ross, 1951)

Plate 35, figures 12-15; Plate 36, figures 1-4, 6-13; Plate 37, figures 6, 11, 12

Kirkella declevita Ross, 1951a, p. 91, Pl. 21, figs. 1-12; Pl. 22, figs. 4, 5; Pl. 23, figs. 1-3.

Kirkella declivata (sic) Ross. Hintze, 1953, p. 183, Pl. 15, figs. 3, 4, 9-12.

Ptyocephalus declivitus (sic) Ross. Fortey, 1975, p. 22.

Occurrences. Highest 30.7 m of Outram Formation; GSC localities, in ascending order: 92298, 92299, 92301, 92303, 92305, 92320, 92321, 92309, 92310, 92323, 92312, 92324 and 92315. Skoki Formation; GSC localities 92316 and 92317, 0.7 m and 6.4 m, respectively, above base of formation. Zone J.

Description and discussion. Ross (1951a, p. 91) speculated that his species *declevitus* might prove to be conspecific with *Ptyocephalus vigilans* Whittington (1948, p. 567, Pl. 82, figs. 1-7; Pl. 83, figs. 1-11), from the Pogonip Formation of Nevada, when the two species were better known. But his separation of the two was later confirmed by Hintze (1953, p. 182), who recorded *P.* cf. *P. vigilans* from low in Zone J and *P. declevitus* from the middle of the same zone.

Ross pointed out that in the hypostoma of *P. vigilans* the lateral margin runs in an unbroken curve from the lateral notch to the posterior border and median notch; in that of *P. declevitus* the lateral margin carries a low rim and there are two breaks in its continuity, so that it appears truncated a short distance behind the lateral notch. The present material (Pl. 37, figs. 6, 12), shows the truncated outline, though the rim is less obvious, and there is some evidence on GSC 62428 (Pl. 37, fig. 6) of a broken, small protuberance as described by Ross. A line joining the posterolateral angles of the pygidial outline was said by Ross to pass through the axial line of the pygidium at a point 0.7 of the length measured from the anterior end in *P. vigilans*, but 0.75 in *P. declevitus*; the corresponding figure in the Wilcox Pass specimens is from 0.75 to just over 0.8 (excluding half ring). Mature pygidia of *P. declevitus* were said to have a length equal to the maximum breadth, whereas those of *P. vigilans* had the length less than the breadth (Ross, 1951a, p. 92). In the present specimens the length is slightly less than the breadth, but the pygidial axis is clearly defined, a criterion indicative of *P. declevitus* rather than of *P. vigilans* according to Ross.

Ptyocephalus acclivus (Hintze, 1953)

Plate 36, figure 5

Kirkella accliva Hintze, 1953, p. 185, Pl. 14, figs. 6, 16, 17; Pl. 15, figs. 1, 2.

Ptyocephalus accliva (Hintze). Young, 1973, p. 110, Pl. 2, figs. 19-21, 23, 24; Pl. 6, fig. 2.

Occurrences. Outram Formation: GSC locality 92289, 154.2 m above base of formation. Questionably at GSC locality 92286, 149.5 m above the base of the Outram Formation. Previous records of the species are from Zone H, but the age, based on other trilobites, at Wilcox Pass is low in Zone J.

Description and discussion. The present specimen, although incomplete, resembles *P. acclivus* in having both a median length that is about four fifths the maximum breadth and an axis that is almost undifferentiated from the plump, smooth pleural fields, that stand well above the broad, almost level border. In *P. declevitus*, the axis is well differentiated and in some cases there are traces of pleural furrows on the pleural fields. The genus proved rare in this part of the Outram Formation, and no indentifiable cranidia were found.

Genus *Trigonocerca* Ross, 1951

Type species. *Trigonocerca typica* Ross, 1951.

Trigonocerca? sp.

Plate 40, figures 11, 13.

Occurrence. Outram Formation, 15 m above its base; GSC locality 92275. Zone G.

Description and discussion. A single, small pygidium, slightly distorted asymmetrically, resembles that of *T. typica* Ross (1951a, p. 104, Pl. 26, figs. 5-8) in overall outline and in development of the lateral border; but the axis is more clearly defined and the segmentation of both axis and pleural fields is better developed. The tip of the pygidium is incomplete, but there is evidence of a terminal spine, the base of which crosses the border as in *T. typica*. Traces of segmentation are visible only on internal moulds of the axis and pleural fields in *T. typica* according to Ross (1951a, p. 105), whereas the present specimen shows ring, pleural and rib furrows on both internal and external moulds. Similar comments apply to large pygidia of *T. typica* illustrated by Hintze (1953, Pl. 11, figs. 6, 9), though a small specimen (loc. cit., Pl. 11, fig. 10) is more strongly segmented. All Ross's and Hintze's material of *Trigonocerca* came from Zone H in Utah; the present specimen is from strata reliably dated as Zone G.

Genus *Megistaspis* Jaanusson, 1956

Type species. *Trilobites limbatus* Boeck, 1838.

Subgenus *Ekeraspis* Tjernvik, 1956

Type species. Plesiomegalaspis (Ekeraspis) armata Tjernvik, 1956.

Megistaspis (Ekeraspis?) sp.

Plate 40, figure 7

Occurrence. Outram Formation, 18.5 m above its base, GSC locality 92276. Zone G (undivided).

Dimensions. Length of cranidium = 14.7 mm; length of combined glabella and occipital ring = 10.6 mm; maximum breadth of glabella = 6 mm (estimated); distance across palpebral lobes = 10 mm.

Description and discussion. An incomplete cranidium illustrated here as a latex cast generally resembles that of *M. (E.) armata* (Tjernvik, 1956, p. 242, Pl. 7, fig. 7) from the lower Arenig of Sweden, but is distinguished by its slightly narrower glabella (breadth = 0.58 of length, compared with 0.64) and anterior area, with the anterior branches of the facial suture meeting at a less obtuse angle. In these respects it compares better with *M. (E.) nevadensis* Ross (1970, p. 80, Pl. 14, figs. 3-5, 8) from the Goodwin Limestone of Nevada, the uppermost part of which belongs to Zone G2 (Ross, 1970, p. 29), though in the latter species the combined anterior border and preglabellar field occupy only 0.2 of the cranidial length, compared with approximately 0.27. The corresponding, but even less complete internal mould of the Canadian specimen shows a very faint preglabellar ridge; the external mould shows part of a Bertillon pattern of closely spaced, low ridges on the glabella and palpebral lobes, and coarser ridges on the anterior border.

Subfamily NIOBINAE Jaanusson in Moore, 1959

Genus *Niobella* Reed, 1931

Type species. Niobe Homfrayi Salter, 1866.

Niobella sp.

Plate 40, figure 16

Occurrence. Outram Formation, 35 m above its base. GSC locality 92279. Zone G (undivided).

Dimensions. Length of cranidium = 17.5 m (estimated); length of glabella = 12.5 mm (estimated); maximum breadth of glabella = 8 mm; posterior breadth of cranidium = 18 mm (estimated).

Description and discussion. A single, incomplete cranidium is insufficient for specific determination but resembles *Niobella homfrayi* (Salter, 1866, p. 143, Pl. 20, figs. 3, 4, 6-8, 12), from the Tremadoc of North Wales and *N. homfrayi* var. *smithi* Stubblefield (1933, p. 368, Pl. 34, figs. 3, 4), from the Tremadoc of England, in having the glabellar outline slightly constricted behind centre, opposite the posterior ends of the small palpebral lobes; it differs in that the frontal glabellar lobe is more convex forward, the anterior border is longer, and the posterior branches of the facial suture are shorter and directed more strongly backward.

Niobella sp. of Ross (1970, p. 82, Pl. 14, fig. 14), from the Goodwin Limestone of Nevada, resembles the present specimen in its long anterior border and poorly defined occipital furrow, but its glabella is proportionately shorter (ratio of length:breadth = 4:3 compared with 3:2 approximately).

Subfamily SYMPHYSURININAE Kobayashi, 1955

Genus *Symphysurina* Ulrich in Walcott, 1924

Type species. Symphysurina woosteri Ulrich in Walcott, 1924.

Remarks. Numerous levels within the basal silty member and the putty shale member of the Survey Peak Formation yielded *Symphysurina*, but the material comprises mostly broken fragments and specific identification is generally impractical. The genus is in need of modern revision, and the nomenclature and relationships of many previously described species are far from clear. For present purposes an arbitrary classification has, of necessity, been adopted and specimens are placed as far as possible in groups on the basis of whether the posterior pygidial margin is rounded or produced to form a terminal spine. In many cases, it was not even possible to make this distinction, and in the distribution chart (Fig. 2) *Symphysurina sensu lato* is shown simply as extending from GSC locality 92221 to GSC locality 89287, that is, through the uppermost 20.3 m of the basal silty member and the lowest 26 m of the putty shale member.

For convenience, all relevant species of *Symphysurina* are discussed together at the end of the section.

Symphysurina walcotti Kindle, 1929

Plate 38, figures 1-13; Plate 39, figure 6(?)

Symphysurina walcotti Kindle, 1929, p. 146, Pl. 1, fig. 18; Dean, 1978, p. 2.

Symphysurina brevispicata Hintze, 1953, p. 236, Pl. 3, figs. 9-17.

Holotype. GSC 9378 (Pl. 38, fig. 13).

Dimensions of holotype. Length (excluding half ring) = 4.2 mm, maximum breadth = 10 mm, frontal breadth of axis = 3.2 mm, length of axis = 3.6 mm.

Occurrences. The holotype came from a piece of limestone that probably corresponds to part of the basal silty member of the Survey Peak Formation at "Swift's Ranch", 11.2 km (7 miles) north of Jasper, Alberta. The precise location is not clear but the allegedly associated fauna, including *Missisquoia*, has been discussed elsewhere (Dean, 1978).

At Wilcox Pass, the species was found in the basal silty member at the following GSC localities, in ascending order: 89292, 89275, 89294, 92226, 92227, 89295, 92228 and 92231. These range from 25 m to 35.1 m above the base of the member and belong to Zone A. In Utah, *S. brevispicata* was recorded by Hintze (1953, p. 25, 26) from zones A and B.

Symphysurina spicata Ulrich in Walcott, 1925

Plate 39, figures 1, 3, 4, 7-9, 11, 12

Symphysurina spicata Ulrich in Walcott, 1925, p. 113, Pl. 21, figs. 12-18.

Occurrences. Survey Peak Formation, basal silty member, 17.9 m to 27 m above its base, GSC localities 92222, 89272, 92225 and 89293; putty shale member, 7.5 m above its base, GSC locality 89282. Highest part of *Missisquoia* Zone; Zone A.

Symphysurina sp.

Plate 39, figures 2, 5, 10, 13

Occurrences. Survey Peak Formation, basal silty member, 17.7 m above its base (GSC 62455 at GSC locality 92221, *Missisquoia* Zone), and 27 m above its base (GSC 62445 at GSC locality 89293, Zone A); putty shale member, 17.5 m above its base (GSC 62447, 62452 at GSC locality 89288, Zone A).

Description and discussion. Although *Symphysurina walcotti* was founded on only a single pygidium, the latter resembles in all essentials that of *S. brevispicata*. The outline of Kindle's holotype is more transverse frontally and less rounded anterolaterally than in most of, if not all, the pygidia from Wilcox Pass, but paratypes illustrated by Hintze (1953, Pl. 3, figs. 15a, 16) suggest these differences represent only intraspecific variation. Cranidia now figured (Pl. 38, figs. 1-6) closely resemble Hintze's illustrated specimens (loc. cit., Pl. 3, figs. 9b, 11, 14); the latter, in turn, show the palpebral lobes to be proportionately shorter in a large than in a small cranidium (0.24 of median cranidial length, compared with 0.3). A librigena from a boulder in western Newfoundland was assigned to *S. brevispicata* by Fortey et al., 1982, p. 114, Pl. 3, fig. 16), but has an eye still longer than any seen at Wilcox Pass or in Utah, and its identity is uncertain.

Symphysurina spicata, founded on material from thin bedded limestone in the Goodwin Formation of the Eureka district, Nevada, has a particularly distinctive terminal spine that declines posteriorly with respect to the plane of the ventral surface of the pygidium (Walcott, 1925, Pl. 21, fig. 17). Similar declination is seen in the Wilcox Pass pygidia, in which the size of the spine increases with that of the pygidium. Elsewhere in the southern Canadian Rockies *Symphysurina*? *entella* Walcott (1925, p. 112, Pl. 21, figs. 19-24, 30) and *S. eugenia* Walcott (1925, p. 113, Pl. 21, figs. 25-32) were described from the Mons Formation at "Clearwater Canyon", 34 km north of Lake Louise. Mons Formation, now obsolete, corresponds mainly to the Survey Peak Formation. Walcott's species are inadequately known at present but both were stated to have a spinose pygidium.

Of the pygidia referred here to *Symphysurina* sp., the original of Pl. 39, fig. 2 has a narrower axis and relatively larger pleural regions than either *S. spicata* or *S. uncaspicata* Hintze (1953, p. 233, Pl. 2, figs. 5-7) and may, perhaps, be better compared with the pygidium of *S.*? *entella* Walcott (1925, Pl. 21, fig. 30). The remaining pygidia (Pl. 39, figs. 5, 10, 13) are all proportionately longer and less convex, both longitudinally and transversely, than *S. walcotti*, but are insufficient for detailed comparison.

Genus *Bellefontia* Ulrich in Walcott, 1924

Type species. Hemigyraspis collieana Raymond, 1910.

Bellefontia nonius Walcott, 1925

Plate 40, figures 1-4, 6, 8, 12

Bellefontia nonius Walcott, 1925, p. 72, Pl. 23, figs. 7-11; Lochman and Duncan, 1950, p. 351, Pl. 52, figs. 1-4; Ross, 1951a, p. 97, 98.

Occurrences. In ascending order: Survey Peak Formation, putty shale member, GSC localities 92233, 92234; middle member, GSC localities 92235, 92236, 92237, 92238. Total thickness = 33.8 m. Zone B.

Dimensions (in mm). All refer to internal moulds.

	GSC 83531	GSC 83532	GSC 83533
Median length of cranidium	11.1	-	-
Frontal breadth of cranidium	10.1	-	-
Frontal breadth of glabella	6.0	-	-
Distance across palpebral lobes	10.3	-	-
Overall breadth of pygidium	-	9.8	11.0
Median length of pygidium	-	5.3	5.2
Frontal breadth of axis	-	2.6	2.3

Description and discussion. Pygidia (Pl. 40, figs. 2, 3) from Wilcox Pass are indifferently preserved in a calcareous siltstone matrix but agree with syntypes (Walcott, 1925, Pl. 23, figs. 10, 11) from the "Mons Formation" at "Clearwater Canyon", about 34 km north of Lake Louise rail station, Alberta. Noteworthy points of resemblance include the conspicuous lateral border, which broadens (exsag.) anterolaterally, and the pair of deep pleural furrows set immediately behind the ridge-like anterior half-ribs; the latter merge abaxially with the lateral border. In both sets of material, the relatively narrow, distinct axis (0.25 of pygidial breadth) is slightly funnel-shaped in form, with a break in outline at the third or fourth ring furrow; there are seven or eight axial rings, progressively less well defined from front to rear and separated by transversely straight ring furrows that are slightly shallower medially.

Comparison of associated cranidia (Pl. 40, figs. 4, 6) with those of *B. nonius* is more equivocal, but the anterior border is of similar breadth though possibly better defined. An incomplete left librigena (Pl. 40, fig. 12) agrees, as far as comparison is possible, with a syntype right librigena figured by Walcott (1925, Pl. 23, fig. 9).

Genus *Parabellefontia* Hintze, 1953

Type species. Parabellefontia concinna Hintze, 1953.

Parabellefontia concinna Hintze, 1953

Plate 41, figures 1-15(?)

Parabellefontia concinna Hintze, 1953, p. 194, Pl. 3, figs. 1-8; Jaanusson in Moore, 1959, p. O353, Fig. 262, 5a-c.

Occurrences. Found at only two levels in the middle member of the Survey Peak Formation, at GSC localities 92236 and 92237, 29.6 m and 30 m, respectively, above the base of the member. In Utah the species was said to occur "high in Zone B" (Hintze, 1953, p. 195).

Dimensions (in mm). All refer to internal mould; (estd.) = estimated.

	GSC 83536	GSC 83542	GSC 83539	GSC 83541
Frontal breadth of cranidium	4.2	8.3	-	-
Median length of cranidium	4.7	9.8	-	-
Distance across palpebral lobes	5	9 (estd.)	-	-
Median length of pygidium	-	-	18	9.5
Maximum breadth of pygidium	-	-	30	15
Frontal breadth of axis	-	-	8	4.3

Description and discussion. The fragmentary and often exfoliated Canadian specimens agree closely with, and are generally larger than, the silicified type material from Utah. Little need be added to Hintze's original description and Jaanusson's supplementary remarks (see synonymy) but the following points may be noted. On the external cranidial surface the glabella is almost undifferentiated, but the internal mould of a small cranidium 11.8 mm long (Pl. 41, figs. 1, 2) has the preglabellar furrow and the anterior halves of the axial furrows well defined. The median glabellar tubercle is very small, not readily apparent, sited opposite the mid-points of the palpebral lobes. Two incomplete librigenae (Pl. 41, figs. 5, 14) show distinct, closely spaced pits on the external surface.

Although the pygidial axis is poorly defined externally (Hintze, 1953, Pl. 3, figs. 7, 8b), it is more clearly defined on internal moulds, e.g., Pl. 41, figs. 3, 9. The latter show seven transversely straight axial rings, separated by ring furrows that are shallow medially, where there is a faint suggestion of a median ridge. One specimen (Pl. 41, fig. 9) retains the terminal piece, which is small and bifid. The well defined, narrow, concave pygidial border is conspicuous, particularly on internal moulds (e.g., Pl. 41, figs. 6, 8, 9); it almost coincides with the doublure whose inner margin is strongly flexed dorsally.

The hypostoma was not available to Hintze but a single specimen from Wilcox Pass (Pl. 41, fig. 15) may belong to the species. Though incomplete, it has a convex middle body that is ovoid in outline, slightly longer than wide. There is no clear evidence of a median furrow or maculae and the surviving anterior wing is small, obliquely truncated, passing into an anterior border that narrows (exsag.) adaxially. Compared with the hypostoma of *Symphysurina*, exemplified by *S. uncaspicata* Hintze, 1953 as figured by Jaanusson (in Moore, 1959, Fig. 262, 3c), the Albertan specimen is relatively longer and the anterior lobe of the middle body is more strongly convex forward.

Unassigned asaphid hypostomata

Asaphid trilobites are more abundant in the Outram Formation than in the Survey Peak Formation, and several hypostomata found there cannot be assigned to the genera and species known from either formation. The material is illustrated and brief comments are made at the end of the section.

Asaphid hypostoma A

Plate 37, figures 1, 4

Occurrence. Outram Formation, 237.6 m above its base, GSC locality 92319. Zone J.

Asaphid hypostoma B

Plate 37, figures 2, 3, 13

Occurrences. Outram Formation: GSC locality 92276, 18.5 m above base (GSC 62427), Zone G; GSC locality 92288, 151.2 m above base (GSC 62425), Zone J.

Asaphid hypostoma C

Plate 37, figure 5

Occurrence. Outram Formation, 18.5 m above base, GSC locality 92276. Zone G.

Asaphid hypostoma D

Plate 37, figure 7

Occurrence. Outram Formation, 230.7 m above base, GSC locality 92300. Zone J.

Asaphid hypostoma E

Plate 37, figures 8-10

Occurrence. GSC locality 92301, 231 m above base. Zone J.

Description and discussion. Hypostoma A, with median length 6 mm, is about 1.5 times as broad as it is long, in contrast to the holotype hypostoma of *Lachnostoma latucelsum* Ross (1951a, Pl. 21, fig. 20) in which the corresponding factor is 1.2. Nevertheless, like that species, hypostoma A has a narrow median notch and the margin of the posterior wings carries three pairs of points. In the Canadian specimen, the surface is ornamented with anastomosing, coarse terrace lines subparallel to the margin and the maculae are directed less strongly forward abaxially. Hypostoma B generally resembles that of *P. (Plesiomegalaspis) estonica* Tjernvik (1956, Pl. 6, fig. 13), from the Arenig of Sweden, but has slightly smaller posterior wings and a relatively shorter median body. Hypostoma C, only 2.5 mm (estimated) long, bears some resemblance to B but has a proportionately larger posterior lobe and longer posterior wings. Though incomplete, there is a small median notch and the posterolateral margin of the remaining posterior wing carries a small, pointed projection sited at the end of a faint ridge that runs adaxially forward across the wing. Weakly developed, closely spaced transverse ridges cover the surface of the median body.

Hypostoma D may be congeneric with that from Zone J of Utah recorded by Hintze (1953, Pl. 20, fig. 17) as *Lachnostoma*? sp., from which it differs only in having a slightly convex anterior margin and broader posterior wings, while the point in the median notch is difficult to distinguish. Hintze's specimen cannot be assigned to *Lachnostoma* and has more in common with the hypostoma of *Pseudonileus wildeni* Hintze (1953, Pl. 15, fig. 16), later the type species of *Protopresbynileus* Hintze, 1954. Hypostoma E is conspicuously long and narrow overall, with the median body extending to the anterior margin; the anterior wings arch strongly backward and the deep median notch is almost parallel-sided. All the surface, excluding furrows, is covered with strong, anastomosing ridges. A general comparison may be made with the hypostoma of *M.* (*Megalaspides*) *dalecarlicus* (Holm) and of *M.* (*Lannacus*) *nericiensis* Wiman, from the Arenig of Sweden, illustrated by Tjernvik (1956, Pl. 8, figs. 8, 9; Pl. 9, fig. 4), though both the latter have a shorter median body, correspondingly longer median notch and longer posterior wings.

Family uncertain

Genus *Clelandia* Cossman, 1902

Type species. Harrisia parabola Cleland, 1900.

Clelandia albertensis Norford, 1969

Plate 29, figures 1-10, 12, 13, 15

Clelandia albertensis Norford, 1969b, p. 8, Pl. 1, figs. 15-18, 22-40.

Occurrences. Survey Peak Formation, GSC localities, in ascending order: basal silty member, 92226, 89295, 92228, 92229, 92231, 89267 and 92232; putty shale member, 89282, 89296, 89285, 89284 and 92234. These range from 30.8 m to 38 m above the base of the basal silty member, and from 7.5 m to 41.8 m above the base of the putty shale member. Zone A.

Description and discussion. In a revision of *Clelandia* in the southern Canadian Rocky Mountains, Norford (1969b, p. 9) stated that the only species with lateral glabellar furrows are *C. texana* Winston and Nicholls, 1967 and *C. parabola* (Cleland, 1900), each with two pairs, and *C. albertensis* Norford, 1969b with one pair. Much of the present sample comprises cranidia that generally resemble, but are notably larger than, the type material of *C. albertensis*; although the smallest specimens (Pl. 29, figs. 10, 12) show only the 1p furrows clearly, with a faint indication of a 2p pair, the largest glabellae have the 2p furrows distinctly developed. The length and maximum breadth of the holotype cranidium of *C. albertensis* were, respectively, 2.75 mm and 4 mm; the corresponding figures for GSC 62340 (Pl. 29, figs. 1, 2, 5, 6) are 4 mm and 6.75 mm.

The occipital ring of *C. albertensis* is large and of distinctive shape; the median half is long (sag.) and parallel-sided, but the distal quarters shorten (exsag.) to form crescentic occipital lobes that curve forward and inward to almost coalesce with the 1p glabellar lobes (Pl. 29, figs. 1, 4, 7, 13). The median half of the occipital furrow is transversely straight, deep medially, then shallowing slightly; the distal portions are occupied by a pair of conspicuous, deep occipital pits (Pl. 29, figs. 4, 7), in front of which the occipital furrow is very shallow and curves anterolaterally to meet the axial furrows slightly behind a transverse line through the centres of the 1p lobes. The resulting lateral indentations of the axial furrows are occupied by a pair of elongated bacculae, each bounded abaxially by a shallow furrow, at the inner posterolateral corners of the fixigenae. Similar structures in *Clelandia parabola* were described as "very small fixigenal nubs" by Norford (1969b, p. 5), who did not record corresponding structures in *C. albertensis*; their presence in the present material may reflect size difference. The apex of the occipital ring carries what was described in smaller specimens (Norford, 1969b, p. 9) as a "low mesial node"; in the present, larger specimens, the structure is strongly developed, composed of two nodes closely grouped in tandem. The anterior, and larger, node is apparently steeply inclined posteriorly; the smaller, slimmer, posterior node forms a gently inclined extension of the margin of the occipital ring. Two distinct, median spines in tandem are seen in *Clelandia bispina* Ross (1967, p. D31, Pl. 10, figs. 1-16), from the Goodwin Limestone of California, and *C. wilsoni* Norford (1969b, p. 10, Pl. 2, figs. 1-17), from the Survey Peak Formation at Mount Wilson, Alberta, but in each of these species the anterior spine is developed in front of the occipital furrow and coincides with a median indentation in the top of the occipital spine. *Clelandia texana* Winston and Nicholls (1967, p. 89), described from the Wilberns Formation of Texas and reported also from the Survey Peak Formation in British Columbia (Norford, 1969b, p. 7), resembles *C. albertensis* in the parabolic glabellar outline with two pairs of glabellar furrows, and in the form of the occipital ring, which becomes markedly narrow (exsag.) distally. But in the Texan species the whole occipital furrow is conspicuously straight transversely and the ends of the occipital ring appear to coalesce with the inner posterolateral corners of the fixigenae instead of curving forward and inward toward the 1p glabellar lobes.

Among the trilobites from the Eureka district of Nevada is a small cranidium from the Goodwin Formation, described by Walcott (1884, p. 94) as *Ptychoparia*? *annectans* and later made type species of *Desmetia* Walcott (1925, p. 83, Pl. 15, figs. 24, 25). The holotype, figured here for comparison (Pl. 42, fig. 15), resembles *Clelandia* in the position of the eyes and course of the facial suture, the long anterior area without clearly defined anterior border, and the development of the 1p and 2p glabellar furrows. As in *C. texana* the occipital furrow is transversely straight, shallow both medially and distally, where the narrow (exsag.) ends of the occipital ring merge with the 1p glabellar lobes, though the glabellar outline is more broadly rounded. The species is insufficently well known to decide whether *Desmetia* is a junior subjective synonym of *Clelandia*, but is referred questionably to the latter genus.

Clelandia sp.

Plate 29, figures 11, 14, 16

Occurrence. Survey Peak Formation, basal silty member. GSC locality 89293. Zone A.

Description and discussion. The oldest examples of *Clelandia* in the present sampling have the anteriorly postioned eyes, facial suture and almost flat anterior area typical for the genus but differ from other species in the less tapered glabellar outline and the shallow occipital furrow; there is no clear indication of occipital lobes, but the occipital ring and 1p glabellar lobes almost coalesce. The median node on the occipital ring is low, sited just behind centre. There is little evidence of lateral furrows on the external surface of the glabella but an internal mould (Pl. 29, fig. 14) had distinct 1p and 2p pairs plus traces of a 3p pair that apparently does not

attain the axial furrows; the same specimen has the front of the glabella bluntly rounded and there is a weakly developed structure resembling a median plectrum (Öpik, 1967, p. 58) in the preglabellar furrow. No satisfactory comparison has been made and the species may be new.

Genus *Pseudoclelandia* Ross, 1951

Type species. ***Pseudoclelandia corrupsittaca*** Ross, 1951.

Although the present material sheds no further light on the systematic position of the genus it is agreed that, as asserted by Ross (1951a, p. 118), there is no evidence of any relationship of *Clelandia* and the two belong probably in separate families.

Pseudoclelandia corrupsittaca Ross, 1951

Plate 28, figures 4, 8

Pseudoclelandia corrupsittaca Ross, 1951a, p. 119, Pl. 29, figs. 11-13, 16, 19.

Occurrence. Survey Peak Formation, upper massive member, 43.8 m above its base. GSC locality 92265. Zone F.

Description and discussion. Although incomplete, the present specimen conforms closely with Ross's original illustrations. The medial widening (sag.) of the anterior border and the presence of a longitudinal furrow linking the well defined anterior border furrow with the deep preglabellar furrow are particularly characteristic, and confusion with other species is unlikely. The species was described first from Zone F in Utah and the single occurrence at Wilcox Pass is of similar age.

Pseudoclelandia fluxafissura Ross, 1951

Plate 28, figures 11, 12, 14

Pseudoclelandia fluxafissura Ross, 1951a, p. 119, Pl. 29, figs. 14, 17, 18; Terrell, 1973, p. 88, Pl. 4, figs. 4, 7.

Occurrence. Survey Peak Formation, middle member, 17.7 m below its top. GSC locality 92258. Zone E.

Dimensions. Median length of cranidium = 3.4 mm, median length of combined glabella and occipital ring = 2.3 mm, overall breadth of cranidium = 5 mm, maximum breadth of glabella = 1.7 mm.

Description and discussion. Ross's type material came from Zone F in Utah but ***Pseudoclelandia*** aff. ***P. fluxafissura*** was later described from Zone E elsewhere in the same region by Hintze (1953, p. 214). Terrell (1973, p. 88) has since reported the species, at least tentatively, from the upper portion of Zone D, as well as from Zone E (though not from Zone F) in rocks of the Lower Fillmore Formation, Utah. Although said by Terrell to be relatively common in Utah, only one example has so far been found in the Canadian Rockies; but the species is very small and could be easily overlooked. In all cases only cranidia are known.

A few cranidia from Zone E in Utah assigned to ***P. fluxafissura*** by Terrell (1973, Pl. 4, fig. 4 only) have unusually coarse ornamentation but were regarded by Terrell as insufficiently distinct for consideration as a new species.

Genera and species undetermined

Gen. et sp. indet. A

See discussion of ***Tesselacauda flabella.***

Gen. et sp. indet. B

Plate 9, figure 11

Occurrence. Survey Peak Formation, basal silty member, GSC locality 89290, 22.2 m above base. Zone A.

Description and discussion. Two left librigenae figured as a latex cast are incomplete anteriorly but may be of olenid type. They have low, narrow, posterior and lateral borders and slim librigenal spines similar to those of ***Parabolinella***, as in, for example, ***P. prolata*** Robison and Pantoja-Alor (1968, (Pl. 102, fig. 9) from the Tremadoc of southern Mexico.

Gen. et sp. indet. C

Plate 13, figures 11, 12

Occurrence. Survey Peak Formation, basal silty member, GSC locality 92211, 7.6 m above base. Zone uncertain; between ***Corbinia apopsis*** Zone and ***Missisquoia*** Zone.

Description and discussion. A single, small cranidium has the glabella as broad as it is long, subtrapezoidal in outline, and bluntly rounded frontally. A well defined, transversely straight occipital furrow delimits an occipital ring that is triangular in plan, with a median node at its posterior extremity. There are three pairs of faint, slightly curved, equispaced glabellar furrows, and the poorly preserved palpebral lobes are sited approximately opposite the 2p glabellar lobes. The frontal area has median length (sag.) about one third that of the glabella; the low anterior border and equally broad (sag.) preglabellar field are separated by a shallow anterior border furrow. The surface is finely granulate. The tapered glabella, low anterior border, triangular occipital ring and transversely straight occipital furrow are features in common with ***Plethopeltis arbucklensis*** Stitt (1971, p. 35, Pl. 8, figs. 10-15), from the ***Missisquoia*** Zone of Oklahoma. The Canadian specimen differs in its granulate surface, relatively shorter frontal area, longer anterior border and larger posterior area of the fixigenae.

Gen. et sp. indet. D

See discussion of ***Hillyardina*** sp.

Gen. et sp. indet. E

Plate 18, figure 1

Occurrence. Survey Peak Formation, middle member, GSC locality 92252, 166.8 m above base. Zone E.

Description and discussion. A fragment of strongly convex pygidium shows the remnants of three deeply furrowed pleural segments; the axis is wide (frontal breadth approximately 0.8 of length) with three well defined axial rings, traces of a fourth, and a weakly bilobed terminal piece.

The postaxial field declines steeply but the posterior margin is not preserved. There is a superficial resemblance to *Carolinites* (compare Pl. 18, figs. 8, 11), but the tuberculate ornamentation is inappropriate and more indicative of a hystricurid.

Gen. et sp. indet. F

Plate 19, figures 9, 11

Occurrences. Outram Formation; GSC locality 92298, 229.3 m above base (GSC 62267), Zone J; GSC locality 92315, 20 cm below top of formation (GSC 62266), Zone J.

Description and discussion. Two incomplete librigenae show subrounded genal angles, and holochroal visual surfaces whose ventral margin is circumscribed by a broad furrow and eye platform. The border is ornamented with faint, anastomosing raised lines. The eyes are set too far back for *Presbynileus* and are both too short and too far from the lateral margin for *Benthamaspis*. The visual surfaces are too large and set too close to the margin for *Ptyocephalus*. No appropriate cranidia were found.

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APPENDIX 1

List of fossil localities

Numbers are Geological Survey of Canada locality numbers, and are arranged in descending stratigraphic order. Not all localities yielded identifiable trilobites.

SKOKI FORMATION (lowest 6.4 m)
Zone J (part) (metres above base of formation)

GSC loc. 92317	6.4 m
GSC loc. 92316	0.7 m

OUTRAM FORMATION (266 m)
Zone J (part) (metres above base of formation)

GSC loc. 92315	265.8 m
GSC loc. 92314	265.6 m
GSC loc. 92313	265.4 m
GSC loc. 92324	265.0 m
GSC loc. 92312	263.6 m
GSC loc. 92311	263.1 m
GSC loc. 92323	261.5 m
GSC loc. 92322	257.2 m
GSC loc. 92310	256.0 m
GSC loc. 92321	253.8 m
GSC loc. 92309	253.1 m
GSC loc. 92308	243.4 m
GSC loc. 92320	243.3 m
GSC loc. 92307	242.0 m
GSC loc. 92306	240.2 m
GSC loc. 92319	237.6 m
GSC loc. 92305	237.3 m
GSC loc. 92304	236.0 m
GSC loc. 92303	232.0 m
GSC loc. 92302	231.3 m
GSC loc. 92301	231.0 m
GSC loc. 92300	230.7 m
GSC loc. 92299	230.7 m
GSC loc. 92298	229.3 m
GSC loc. 92297	229.3 m
GSC loc. 92296	227.8 m
GSC loc. 92318	214.8 m
GSC loc. 92295	212.0 m
GSC loc. 92294	196.7 m
GSC loc. 92293	168.5 m
GSC loc. 92292	168.0 m
GSC loc. 92291	166.7 m
GSC loc. 92290	165.0 m
GSC loc. 92289	154.2 m
GSC loc. 92288	151.2 m
GSC loc. 92287	150.6 m
GSC loc. 92286	149.5 m

Zones H and I (undifferentiated)

This part of the succession is represented by 89.5 m of almost barren strata in which the only indentifiable trilobite was *P. (Presbynileus) latifrons*.

GSC loc. 92285	135.2 m

Zone G (undivided) (metres above base of formation)

GSC loc. 92284	60.0 m
GSC loc. 92283	58.8 m
GSC loc. 92282	52.5 m
GSC loc. 92281	50.2 m
GSC loc. 92280	40.5 m
GSC loc. 92279	35.0 m
GSC loc. 92278	32.0 m
GSC loc. 92277	29.0 m
GSC loc. 92276	18.5 m
GSC loc. 92275	15.0 m
GSC loc. 92274	13.6 m
GSC loc. 92273	12.0 m
GSC loc. 92272	9.5 m
GSC loc. 92271	9.0 m
GSC loc. 92270	5.2 m

SURVEY PEAK FORMATION

d. upper massive member (78.5 m)

Zone F (metres above base of member)

GSC loc. 92268	77.9 m
GSC loc. 92267	73.9 m
GSC loc. 92266	60.2 m
GSC loc. 92265	43.8 m

Zone E (part) (metres above base of member)

GSC loc. 92264	26.5 m
GSC loc. 92263	9.5 m

c. middle member (199 m)

Zone E (part) (metres above base of member)

GSC loc. 92262	194.7 m
GSC loc. 92261	190.3 m
GSC loc. 92260	188.7 m
GSC loc. 92259	184.5 m
GSC loc. 92258	181.3 m
GSC loc. 92257	172.0 m
GSC loc. 92256	171.3 m
GSC loc. 92255	170.2 m
GSC loc. 92254	169.5 m
GSC loc. 92253	169.0 m
GSC loc. 92252	166.8 m
GSC loc. 92251	164.8 m
GSC loc. 92250	160.5 m
GSC loc. 92249	158.7 m

Zonal position uncertain
(metres above base of member)

GSC loc. 92248	154.0 m
GSC loc. 92247	119.7 m

Zone D

GSC loc. 92246	90.1 m
GSC loc. 92245	88.6 m
GSC loc. 92244	85.9 m
GSC loc. 92243	82.1 m
GSC loc. 92242	75.0 m
GSC loc. 92241	61.2 m
GSC loc. 92240	60.6 m

Zone C

GSC loc. 92239	50.1 m

This level yielded only undetermined asaphid? fragments, not included in the present account.

Zone B (part) (metres above base of member)

GSC loc. 92238	33.0 m
GSC loc. 92237	30.0 m
GSC loc. 92236	29.6 m
GSC loc. 92235	11.2 m

c. putty shale member (42 m)

Zone B (part) (metres above base of member)

GSC loc. 92234	41.8 m
GSC loc. 92233	41.2 m

Zone A (part) (metres above base of member)

GSC loc. 89287	26.0 m
GSC loc. 89288	17.5 m
GSC loc. 89298	14.0 m
GSC loc. 89286	13.6 m
GSC loc. 89289	13.1 m
GSC loc. 89284	12.5 m
GSC loc. 89283	12.0 m
GSC loc. 89285	11.8 m
GSC loc. 89297	11.5 m
GSC loc. 89296	11.0 m
GSC loc. 89282	7.5 m
GSC loc. 89281	6.8 m
GSC loc. 89280	6.0 m

d. basal silty member (38 m)

Zone A (part) (metres above base of member)

GSC loc. 92232	38.0 m
GSC loc. 89267	36.3 m
GSC loc. 92231	35.1 m
GSC loc. 92230	34.7 m
GSC loc. 92229	34.0 m
GSC loc. 92228	33.1 m
GSC loc. 89295	31.1 m
GSC loc. 92227	30.9 m
GSC loc. 92226	30.8 m
GSC loc. 89294	30.7 m
GSC loc. 89277	27.8 m
GSC loc. 89293	27.0 m
GSC loc. 89278	26.2 m
GSC loc. 89275	25.7 m
GSC loc. 89292	25.0 m
GSC loc. 89276	24.3 m
GSC loc. 89291	22.5 m
GSC loc. 89290	22.2 m
GSC loc. 89270	19.4 m

***Missisquoia* Zone**

GSC loc. 92225	19.2 m
GSC loc. 92224	19.1 m
GSC loc. 89272	18.6 m
GSC loc. 89268	18.4 m
GSC loc. 89271	18.1 m
GSC loc. 89273	18.0 m
GSC loc. 92223	17.9 m
GSC loc. 92222	17.9 m
GSC loc. 92221	17.7 m
GSC loc. 92220	17.4 m
GSC loc. 89269	17.2 m
GSC loc. 92219	17.1 m
GSC loc. 89274	16.1 m
GSC loc. 92218	15.2 m
GSC loc. 92217	14.6 m
GSC loc. 92216	13.8 m
GSC loc. 92215	13.5 m

Zonal position uncertain

GSC loc. 92214	13.2 m
GSC loc. 99213	9.8 m
GSC loc. 92212	9.4 m
GSC loc. 92211	7.6 m

***Corbinia apopsis* Subzone**

GSC loc. 92210	5.9 m
GSC loc. 92209	5.2 m
GSC loc. 92208	4.8 m
GSC loc. 92207	4.7 m
GSC loc. 92206	4.5 m

PLATES 1-42

Most of the figured specimens are housed in the Type Fossil Collection of the Geological Survey of Canada, 601 Booth Street, Ottawa, and have numbers with the prefix GSC. The majority come from the Survey Peak Formation, Outram Formation and lowest Skoki Formation at the measured section at Wilcox Pass and, unless otherwise stated, are from numbered GSC localities there, the stratigraphic positions of which are indicated in the text and Appendix. Other figured specimens are from the United States National Museum, Washington, D.C. (USNM) and the Museum of Comparative Zoology, Harvard University (MCZ). Specimens were whitened with ammonium chloride sublimate before being photographed. Photographs were taken by the author.

PLATE 1

Figure 1. *Neoagnostus aspidoides* Kobayashi, 1955

McKay Group, Jubilee Mountain, southwest of Harrogate, British Columbia

Holotype cephalon, GSC 12745, x 7. (Figured by Kobayashi, 1955, Pl. 7, fig. 5).

Figures 2-11. *Geragnostus* (*Micragnostus*) *chiushuensis* (Kobayashi, 1931)

Survey Peak Formation, middle member

2. Latex cast of cephalon, GSC 62136, x 12; GSC loc. 92246.

8. Internal mould of pygidium, GSC 62137, x 12; GSC loc. 92244.

9. Latex cast of pygidium, GSC 62138, x 12; GSC loc. 92244.

Survey Peak Formation, basal silty member

3, 7. Left lateral and plan views of internal mould of cephalon, GSC 62130, x 12; GSC loc. 89291.

5. Latex cast of pygidium, GSC 62131, x 15; GSC loc. 89293.

10. Internal mould of pygidium, GSC 62132, x 15; GSC loc. 92229.

11. Internal mould of pygidium, GSC 62133, x 12; GSC loc. 89293.

Survey Peak Formation, putty shale member

4. Latex cast of pygidium, GSC 62134, x 11; GSC loc. 89280.

6. Latex cast of cephalon, GSC 62135, x 11; GSC loc. 89280.

Figures 12-16. *Carinocranium cariniferum* n. gen. et sp.

Outram Formation, GSC loc. 92293

Holotype cranidium, GSC 62139. 12, 15, plan and anterior views of internal mould; 13, 14, 16, left anterolateral, anterior and plan views of latex cast, x 12.

PLATE 1

PLATE 2

Figures 1, 3, 6. *Scotoharpes* sp.

Outram Formation

1. Internal mould of fragmentary cranidium, GSC 62141, x 6; GSC loc. 92288.

3, 6. Plan and right lateral views of latex cast of incomplete cranidium, GSC 62142, x 5; GSC loc. 92297.

Figure 5. *Harpides* sp.

Outram Formation

Latex cast of fragment of cephalic fringe, GSC 62140, x 6; GSC loc. 92308.

Figures 2, 4, 7, 8, 10-12. *Tesselacauda flabella* Kobayashi, 1955

Survey Peak Formation, middle member

2. Fragment of pygidium, GSC 62143, x 5; GSC loc. 92253.

4, 7. Plan and left lateral views of pygidium, GSC 62144, x 5; GSC loc. 92253.

8, 11. Plan and left lateral views of fragmentary pygidium, GSC 62145, x 6; GSC loc. 92253.

10. Fragmentary cranidium with associated *Paenebeltella convexa*, GSC 62146, x 10; GSC loc. 92261.

McKay Group, GSC loc. 7977, north of Brisco Trail, British Columbia

12. Holotype pygidium, GSC 12626, x 3.5;
(Figured by Kobayashi, 1955, Pl. 2, fig. 8a, b).

Figure 9. Gen. et sp. undet. A

Outram Formation, GSC 92281

Latex cast of pygidial (?) fragment, GSC 62147, x 6.

PLATE 2

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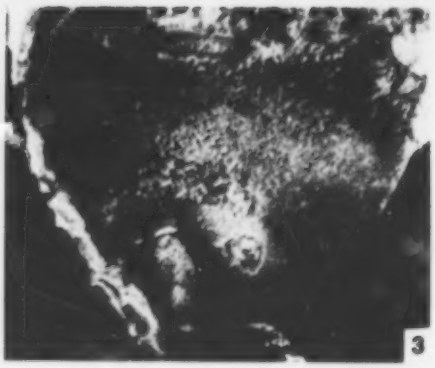
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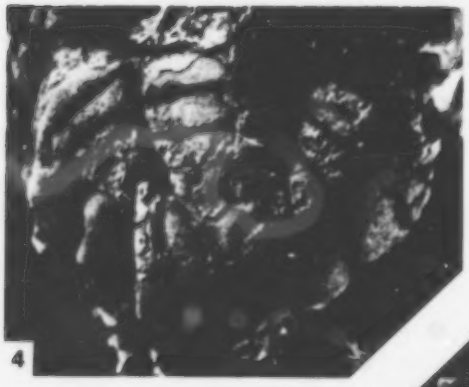
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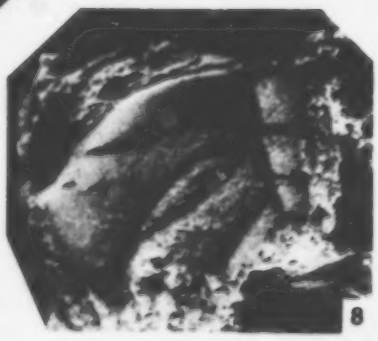
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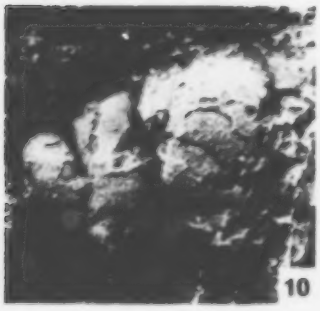
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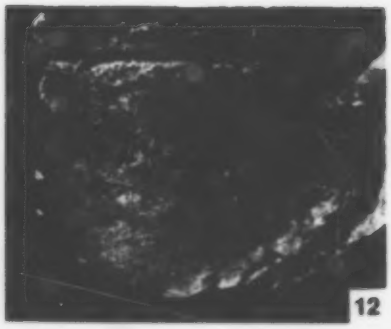
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PLATE 3

Figures 1-5. *Pliomeridius lacunatus* n. sp.

Outram Formation

1, 3, 4. Internal mould of incomplete pygidium, paratype, GSC 62151, x 4; GSC loc. 92300.

2. Latex cast showing tip of axis, GSC 62151.

5. Latex cast of incomplete cranidium, paratype GSC 62152, x 4; GSC loc. 92302.

Figures 6-10. *Cybelopsis speciosa* Poulsen, 1927

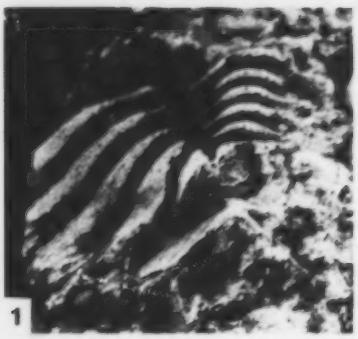
Skoki Formation

6. Internal mould of glabella, GSC 62148, x 4; GSC loc. 92316.

7-9. Left lateral, anterior, and plan views of cranidium, GSC 62149, x 4; GSC loc. 92316.

10. Incomplete, exfoliated cranidium showing pitting on internal mould of glabella, GSC 62150, x 3.5; GSC loc. 92316.

PLATE 3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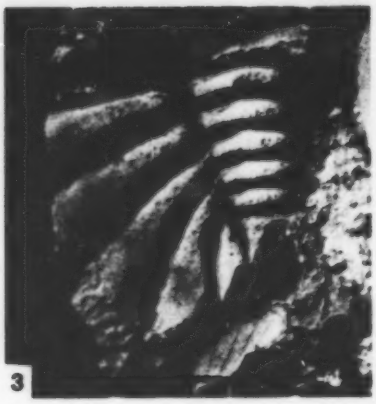
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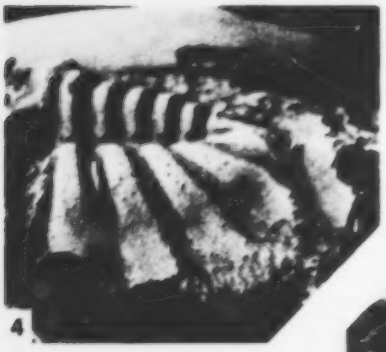
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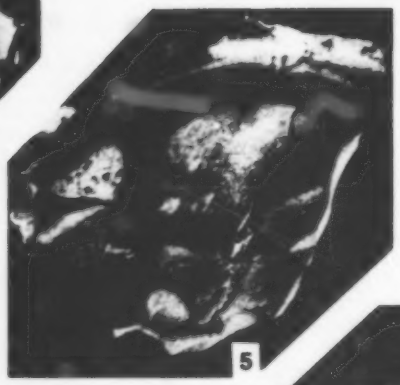
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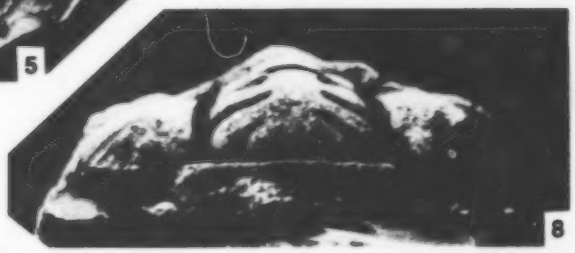
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PLATE 4

Figures 1-3, 5, 6, 8, 9. *Pliomeridius lacunatus* n. sp.

Outram Formation

1-3. Plan, anterior, and left lateral views of internal mould of cranidium, holotype, GSC 62153, x 4; GSC loc. 92286.

5, 8. Latex cast from external mould of same specimen.

6, 9. Plan and oblique right lateral views of incomplete cranidium, paratype, GSC 62154, x 5; GSC loc. 92298.

Figure 4. Pliomerid gen. et sp. indet. 2.

Outram Formation

Small pygidium on weathered rock surface, GSC 62156, x 10; GSC loc. 92276.

Figures 7, 10, 11. ?*Cybelopsis speciosa* Poulsen, 1927

Outram Formation

7, 11. Lateral and plan views of partly exfoliated hypostoma, GSC 62155, x 4; GSC loc. 92323.

10. Latex cast of same specimen.

PLATE 4

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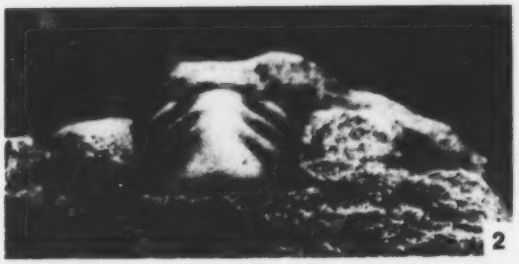
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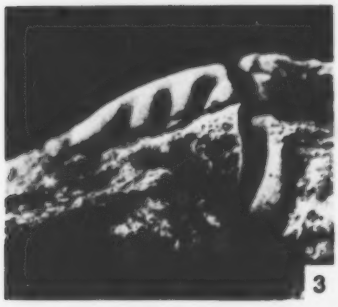
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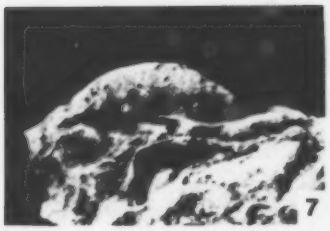
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PLATE 5

Figures 1, 3-6. *Protopliomerops? radiatus* Kobayashi, 1955

McKay Group, 35 m (115 ft) below Mount Wilson Quartzite, McKay Creek (Section 52 of Evans, 1933), British Columbia.

1. Holotype cranidium, GSC 12623, x 2.5; GSC loc. 8139. (Figured by Kobayashi, 1955, Pl. 2, fig. 5a, b).

Outram Formation

3, 5, 6. Anterior, left lateral and plan views of exfoliated cranidium, GSC 62157, x 4; GSC loc. 92307.

4. Incomplete cranidium, GSC 62158, x 4; GSC loc. 92321.

Figure 2. *Protopliomerops? subquadratus* Kobayashi, 1955

McKay Group, GSC loc. 8140, 43 m (139 ft) below Mount Wilson Quartzite, McKay Creek (Section 52 of Evans, 1933), British Columbia.

Holotype cranidium, GSC 12621, x 2.5. (Figured by Kobayashi, 1955, Pl. 2, fig. 3).

Figures 7, 8. *Pliomeridius lacunatus* n. sp.

Outram Formation

7. Incomplete cranidium, paratype, GSC 62159, x 4; GSC loc. 92319.

8. Front of same specimen showing facial suture and median indentation of frontal glabellar lobe, x 6.

PLATE 5

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PLATE 6

Figures 1-6, 8-11. *Pseudocybele nasuta* Ross, 1951

Outram Formation

1. Exfoliated, incomplete cranidium, with pygidium of *P.* (*Presbynileus*) in background, GSC 62160, x 5; GSC loc. 92305.

2, 4, 10. Plan, anterior, and right lateral views of incomplete cranidium, GSC 62161, x 7; GSC loc. 92305.

5. Latex cast of fragmentary cranidium, showing facial suture and part of left palpebral lobe, GSC 62162, x 7; GSC loc. 92305.

8. Incomplete pygidium, GSC 62163, x 9; GSC loc. 92305.

3, 6. Right anterolateral and plan views of latex cast of almost complete cranidium, GSC 62164, x 4; GSC loc. 92300.

9. Slightly distorted fragment of glabella and pitted fixigenal surface, GSC 62165, x 7; GSC loc. 92298.

11. Left anterolateral view of damaged cephalon with librigena in place, GSC 62166, x 4; GSC loc. 92304.

Figure 7. Pliomerid gen. et sp. indet. 1

Survey Peak Formation, middle member

Small, damaged glabella, with associated cranidia of *Paenebeltella convexa* (upper left) and *Hyperbolochilus* cf. *H. expansus* (lower right), GSC 62167, x 10; GSC loc. 92261.

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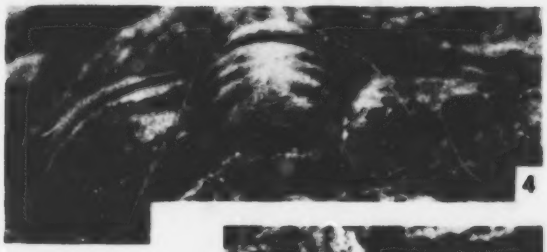
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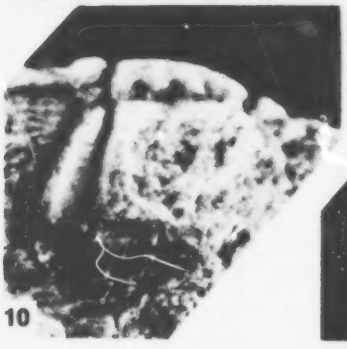
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PLATE 7

Figures 1-11. *Jujuyaspis borealis* Kobayashi, 1955

Survey Peak Formation, putty shale member

1, 2. Plan and oblique left lateral views of incomplete cranidium, GSC 62168, x 5; GSC loc. 92231.

3. Left librigena, GSC 62169, x 8; GSC loc. 92231.

7. Partly exfoliated pygidium, showing ornamentation composed of transverse ridges, GSC 62171, x 6; GSC loc. 92231.

Survey Peak Formation, basal silty member

4-6. Anterior, left lateral, and plan views of incomplete cranidium, GSC 62170, x 5; GSC loc. 89267.

11. Latex cast of incomplete cranidium, GSC 62174, x 5; GSC loc. 89267.

Survey Peak Formation, putty shale member

8. Plan view of left librigena, GSC 62172, x 5; GSC loc. 92229.

10. Oblique left anterolateral view of same specimen showing holochroal eye, facial suture, and pitted surface, x 10.

Survey Peak Formation, putty shale member

9. Latex cast of incomplete cranidium, GSC 62173, x 4; GSC loc. 89284.

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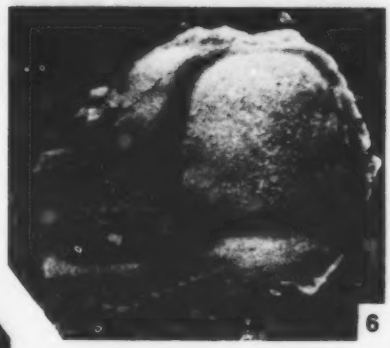
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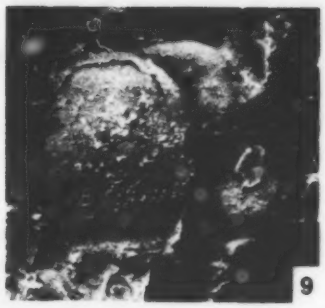
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PLATE 8

Figures 1-3. *Jujuyaspis borealis* Kobayashi, 1955

Survey Peak Formation, putty shale member

1. Small cranidium, GSC 62175, x 8; GSC loc. 89284.

2. Pygidium, GSC 62176, x 8; GSC loc. 89284.

Survey Peak Formation, putty shale member

3. Internal mould of very small (meraspid?) cranidium, GSC 62177, x 5; GSC loc. 89285.

Figures 4-9, 12, 14. *Apoplanias rejectus* Lochman, 1964

Survey Peak Formation, basal silty member

4. Latex cast of cranidium, GSC 62196, x 8; GSC loc. 92212.

Survey Peak Formation, basal silty member

5. Fragmentary cranidium. Note anterior border and ornamentation of preglabellar field, GSC 62197, x 10; GSC loc. 92217.

Survey Peak Formation, basal silty member

6. Latex cast of cranidium. Note palpebral lobes and deep lp glabellar furrows, GSC 62198, x 12; GSC loc. 92214.

Survey Peak Formation, basal silty member

7. Internal mould of cranidium, GSC 62199, x 8; GSC loc. 92207.

Survey Peak Formation, basal silty member

8. Internal mould of front of cranidium, GSC 62200, x 8; GSC loc. 92216.

Survey Peak Formation, basal silty member

9. Internal mould of cranidium, GSC 62201, x 8; GSC loc. 92213.

Survey Peak Formation, basal silty member

12. Cranidium; note median occipital tubercle, GSC 62202, x 6; GSC loc. 92215.

14. Left librigena, GSC 62203, x 6; GSC loc. 92215.

Figures 10, 11, 13. *Paenebeltella convexa* Kobayashi, 1955

McKay Group, GSC loc. 7977, north of Brisco Trail, British Columbia.

10, 11, 13. Right lateral, plan, and anterior views of holotype cranidium, GSC 12729, x 5. (Figured by Kobayashi, 1955, Pl. 7, fig. 21a, b).

PLATE 8

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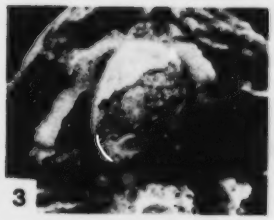
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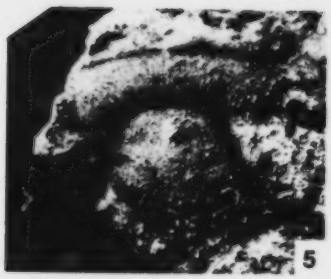
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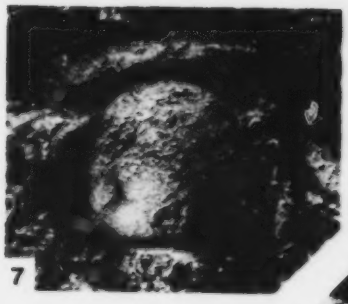
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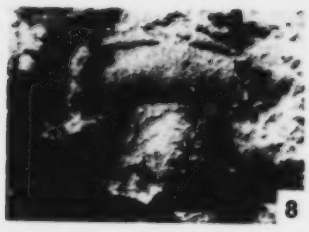
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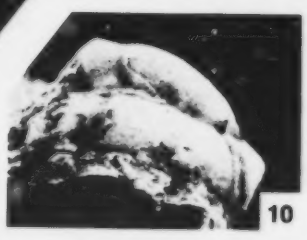
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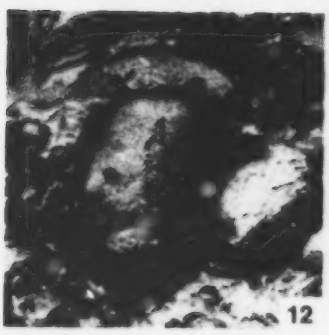
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PLATE 9

Figures 1-6. *Poenebeltella convexa* Kobayashi, 1955

Survey Peak Formation, middle member

1. Fragment of internal mould of cranidium, GSC 62178, x 10; GSC loc. 92257.

Survey Peak Formation, middle member

2, 5. Left anterolateral and plan views of cranidium, GSC 62179, x 9; GSC loc. 92261.

Survey Peak Formation, upper massive member

3, 6. Internal mould and latex cast of cranidium, GSC 62180, x 11; GSC loc. 92264.

Survey Peak Formation, middle member

4. Internal mould of cranidium, GSC 62181, x 7; GSC loc. 92249.

Figures 7-10, 12-14. *Highgatella? cordilleri* (Lochman, 1964)

Survey Peak Formation, basal silty member

7-9. Anterior, left lateral, and plan views of internal mould of cranidium, GSC 62183, x 7; GSC 89292.

Survey Peak Formation, basal silty member

10, 13, 14. Anterior, right lateral, and plan views of partly exfoliated small cranidium, GSC 62185, x 8; GSC loc. 89275.

12. Internal mould of left librigena referred questionably to the species, GSC 62186, x 5; GSC loc. 89275.

Figure 11. Gen. et sp. indet. B

Survey Peak Formation, basal silty member

Latex cast of two left librigenae, GSC 62184, x 7; GSC loc. 89290.

PLATE 9

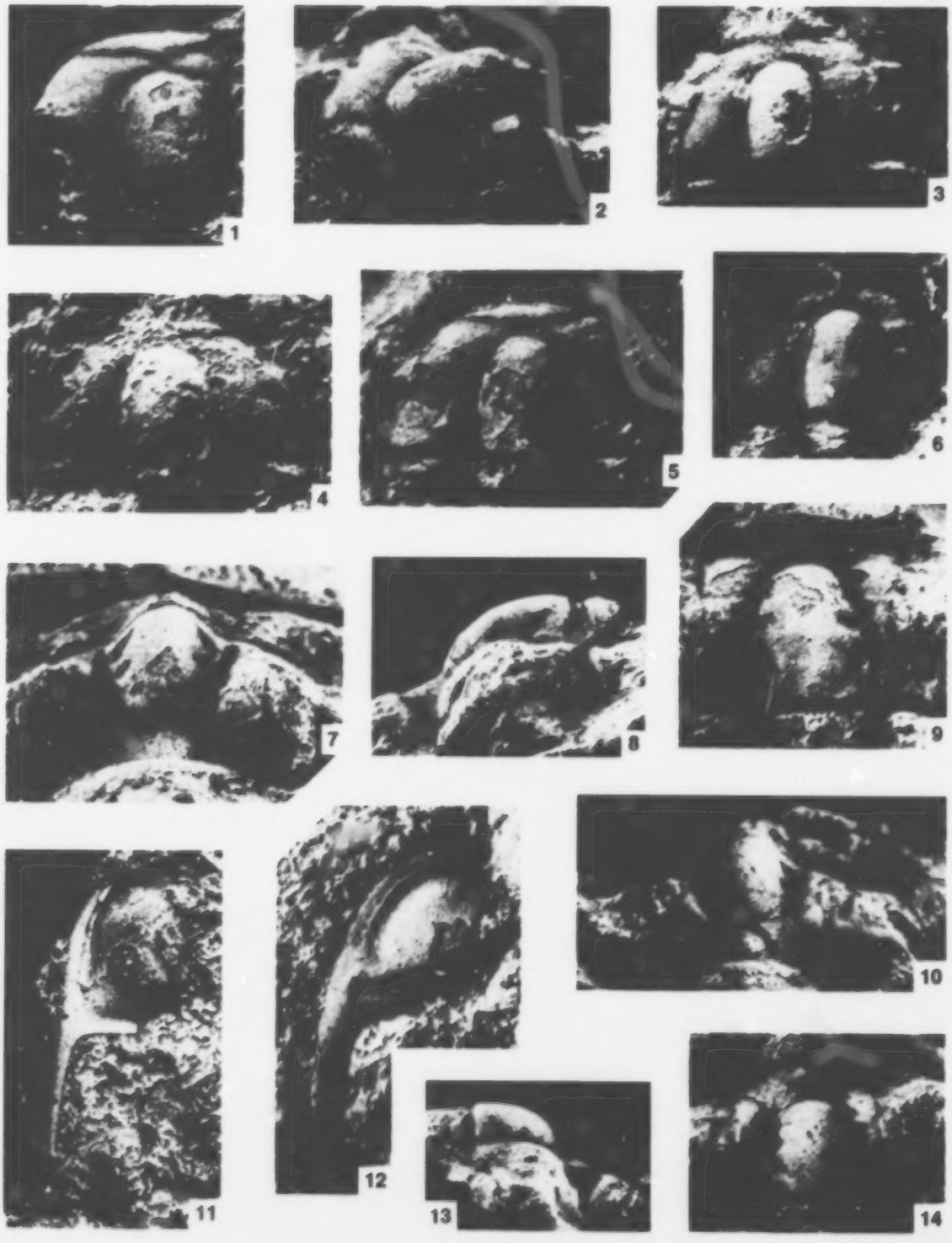


PLATE 10

Figures 1-9. *Highgatella*? *cordilleri* (Lochman, 1964)

Survey Peak Formation, basal silty member

1, 4. Anterior and plan views of internal mould of cranidium, GSC 62188, x 8; GSC loc. 89275.

2. Latex cast of small cranidium, GSC 62189, x 8; GSC loc. 89291.

3. Incomplete, partly exfoliated cranidium, GSC 62192, x 8; GSC loc. 89292.

5. Latex cast of meraspid(?) cranidium, GSC 62190, x 10; GSC loc. 89291.

6, 10. Anterior and plan views of incomplete cranidium, GSC 62194, x 7; GSC loc. 89276.

7. Internal mould of incomplete cranidium, GSC 62193, x 8; GSC loc. 89292.

8. Internal mould of large cranidium. Note occipital tubercle, GSC 62195, x 5; GSC loc. 89276.

9. Internal mould of meraspid(?) cranidium, GSC 62191, x 16; GSC loc. 89291.

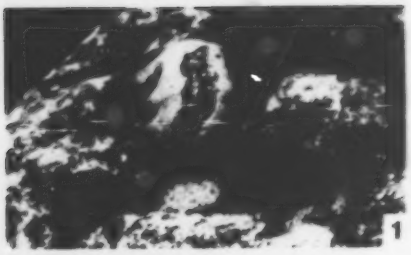
Figures 11-13. *Plethometopus obtusus* Rasetti, 1945

Survey Peak Formation, basal silty member

11, 12. Plan and right lateral views of internal mould of incomplete cranidium, GSC 62204, x 3; GSC loc. 92212.

13. Latex cast of incomplete pygidium, GSC 62205, x 6; GSC loc. 92212.

PLATE 10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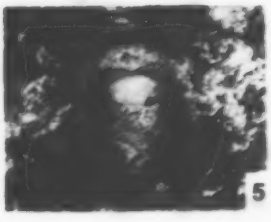
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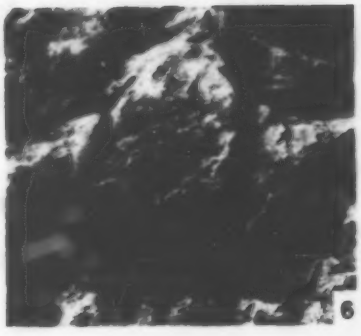
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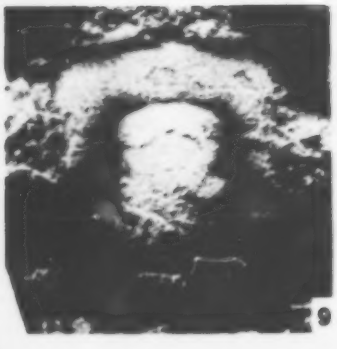
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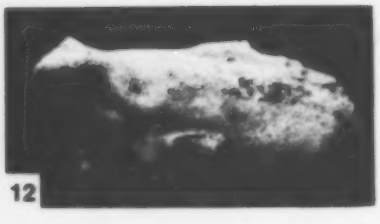
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PLATE 11

Figures 1-7, 9. *Plethometopus obtusus* Rasetti, 1945

Survey Peak Formation, basal silty member

1-3. Plan, anterior, and right lateral views of cranidium, GSC 62206, x 8; GSC loc. 92211.

4, 7. Oblique right lateral and plan views of cranidium, GSC 62207, x 7; GSC loc. 92212.

5, 6, 9. Posterior, left lateral, and plan views of partly exfoliated pygidium showing furrows more strongly developed on internal mould than on external surface, GSC 62208, x 7; GSC loc. 92209.

Figures 8, 10-15. *Corbinia horatio* Walcott, 1924

Survey Peak Formation, basal silty member

8, 11, 12, 15. Plan, left lateral, anterior, and perpendicular views of cranidium, GSC 62209, x 3.5; GSC loc. 92209.

10, 14. Internal mould and latex cast from external mould of cranidium, GSC 62210, x 7; GSC loc. 92210.

13. Latex cast of incomplete cranidium and pygidium, GSC 62211, x 5; GSC loc. 92210.

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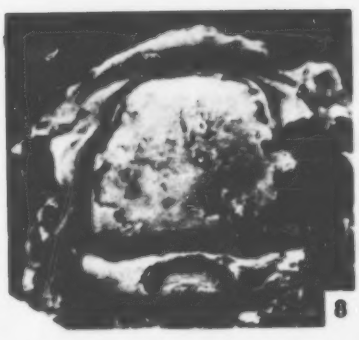
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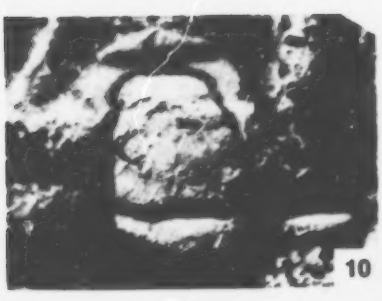
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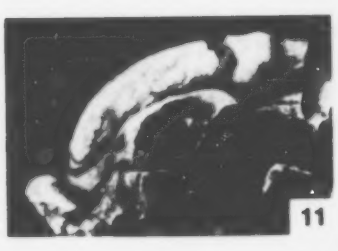
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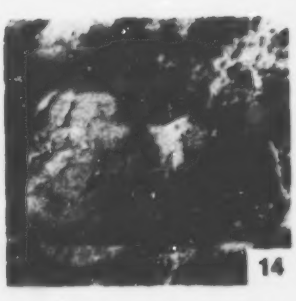
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PLATE 12

Figures 1-12. *Corbinia horatio* Walcott, 1924

Survey Peak Formation, basal silty member

1. Left librigena, GSC 62213, x 8; GSC loc. 92210.

2. Internal mould of incomplete pygidium, GSC 62214, x 6; GSC loc. 92208.

3. Internal mould of fragmentary cranidium, GSC 62215, x 7; GSC loc. 92210.

4. Partly exfoliated left librigena, GSC 62216, x 5; GSC loc. 92206.

5. Internal mould of incomplete cranidium, GSC 62217, x 8; GSC loc. 92207.

7, 10, 12. Right lateral, posterior, and plan views of incomplete pygidium, GSC 62218, x 6; GSC loc. 92207.

Mons Formation, "Clearwater Canyon", northeast of Lake Louise, Alberta.

6. Cranidium, holotype of *Corbinia valida*, USNM 70244, x 2.5. (Figured by Walcott, 1925, Pl. 16, fig. 18).

8. Left librigena, syntype, USNM 70246, x 3. (Figured by Walcott, 1925, Pl. 16, fig. 20).

9, 11. Pygidium (x 4), and pygidium and cranidium (x 3), syntypes, USNM 70248. (Figured by Walcott, 1925, Pl. 16, fig. 22).

PLATE 12

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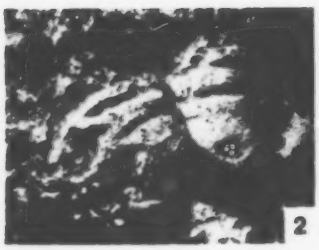
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PLATE 13

Figures 1-5, 7, 13. *Missisquoia typicalis* Shaw, 1951

Survey Peak Formation, basal silty member

1, 2. Plan and posterior views of pygidium lacking tip and axis, GSC 62219, x 10; GSC loc. 92223.

3. Latex cast of small cranidium. Note transverse eye ridges, GSC 62221, x 14; GSC loc. 89269.

4. Small cranidium, GSC 62222, x 15; GSC loc. 89269.

5, 7. Plan and left posterolateral views of pygidium, GSC 62220, x 15; GSC loc. 92223.

13. Right librigena, GSC 62226, x 8; GSC loc. 89269.

Figures 6, 8, 10. *Missisquoia enigmatica* (Kobayashi, 1955)

Survey Peak Formation, basal silty member

6. Internal mould of incomplete small cranidium, GSC 62223, x 12; GSC loc. 89273.

8, 10. Plan and left posterolateral views of internal mould of pygidium, GSC 62224, x 12; GSC loc. 89273.

Figure 9. *Missisquoia* sp.

Survey Peak Formation, basal silty member

Incomplete pygidium, GSC 62225, x 12; GSC loc. 92219.

Figures 11, 12. Gen. et sp. indet. C

Survey Peak Formation, basal silty member

Internal mould and latex cast of cranidium, GSC 62227, x 12; GSC loc. 92211.

PLATE 13

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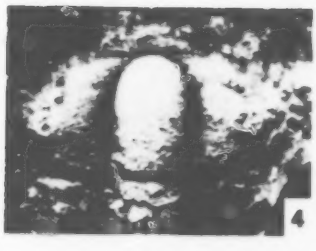
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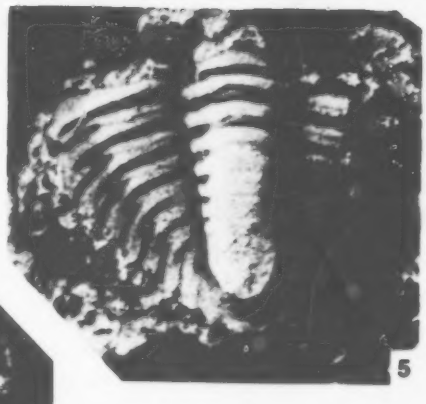
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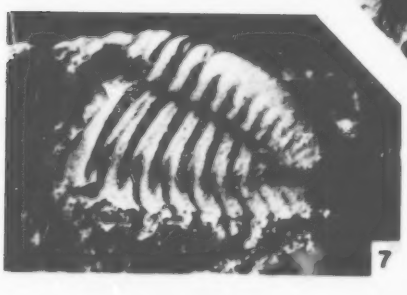
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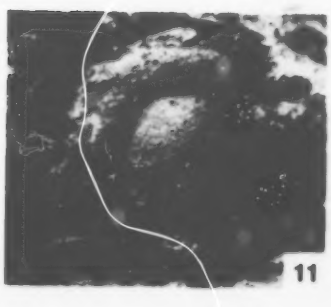
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PLATE 14

Figure 1. Gen. et sp. indet. D

Survey Peak Formation, upper massive member

Incomplete right librigena, GSC 62228, x 6; GSC loc. 92263.

Figures 2, 4, (?)5, (?)6. *Hystricurus oculilunatus* Ross, 1951

Survey Peak Formation, middle member

2. Dorsally compressed cranidium, GSC 62230, x 4; GSC loc. 92261.

4. Small cranidium, GSC 62231, x 10; GSC loc. 92261.

(?)5. Fragmentary pygidium, GSC 62232, x 10; GSC loc. 92261.

(?)6. Latex cast of pygidium, GSC 62233, x 8; GSC loc. 92261.

Figures 3, 11, 13. *Hystricurus* sp.

Survey Peak Formation, upper massive member

3. Abraded cranidium, GSC 62229, x 7; GSC loc. 92263.

11. Part of cephalon showing facial suture and right librigena, GSC 62237, x 5; GSC loc. 92265.

13. Small cranidium with strongly developed eye ridges, GSC 62238, x 7; GSC loc. 92265.

Figures 7, 8. *Pseudohystricurus* sp.

Survey Peak Formation, middle member

Plan and left anterolateral views of internal mould of fragmentary cranidium, GSC 62234, x 12; GSC loc. 92258.

Figures 9, 12, 15. *Hystricurus* cf. *H.* sp. B of Ross, 1951a

Survey Peak Formation, middle member

Plan, right lateral, and anterior views of small cranidium, GSC 62235, x 12; GSC loc. 92257.

Figures 10, 14. *Hystricurus* cf. *H.* sp. A of Ross, 1951a

Survey Peak Formation, middle member

10. Incomplete, exfoliated cranidium, GSC 62236, x 3; GSC loc. 92260.

Survey Peak Formation, middle member

14. Fragment of large cranidium showing longitudinal preglabellar furrow, GSC 62239, x 5; GSC loc. 92252.

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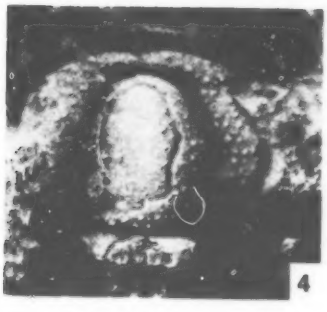
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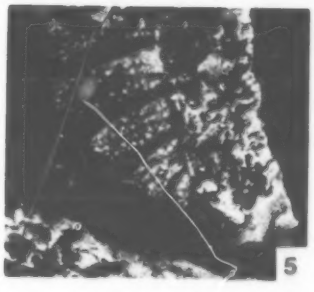
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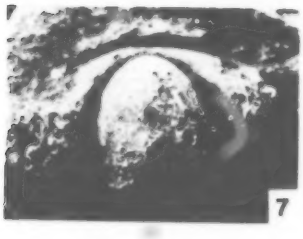
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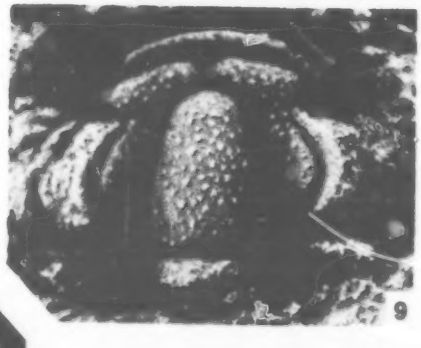
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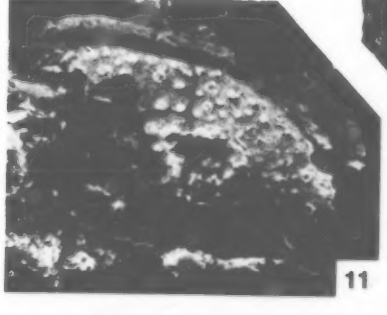
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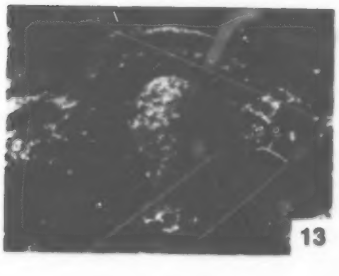
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PLATE 15

Figures 1, 2, 12. *Hystricurus oculilunatus* Ross, 1951

McKay Group, GSC loc. 8106, northeast of Brisco Trail, British Columbia.

1, 2. Plan and left anterolateral views of incomplete cranidium, GSC 12705, x 5. (Holotype of *Vermilionites bisulcatus* Kobayashi, 1955, Pl. 6, fig. 4, the type species of *Vermilionites*.)

Survey Peak Formation, middle member

12. Plan view of latex cast of incomplete cranidium, GSC 62244, x 5; GSC loc. 92249.

Figures 3, 6. *Ischyrotoma eos* (Kobayashi, 1955)

McKay Group, GSC loc. 8064, south of Whiskey Trail, British Columbia.

3, 6. Plan and posterior views of holotype pygidium, GSC 12712, x 5. (Figured by Kobayashi, 1955, Pl. 6, fig. 10). See also Plate 28, figures 1-3, 5, 6.

Figures 4, 5, 7-11, 13, 14. *Hystricurus* sp.

Survey Peak Formation, middle member

4, 5, 7. Anterior, plan, and left lateral views of almost exfoliated cranidium, GSC 62240, x 9; GSC loc. 92259.

Survey Peak Formation, middle member

8, 13. Right anterolateral and plan views of incomplete cranidium, GSC 62241, x 10; GSC loc. 92241.

Survey Peak Formation, middle member

9. Left librigena, showing long, slim, incurved librigenal spine, GSC 62242, x 5; GSC loc. 92254.

10, 11. Plan and lateral views of latex cast of right librigena, GSC 62243, x 5; GSC loc. 92254.

Survey Peak Formation, upper massive member

14. Right librigena, GSC 62245, x 9; GSC loc. 92265.

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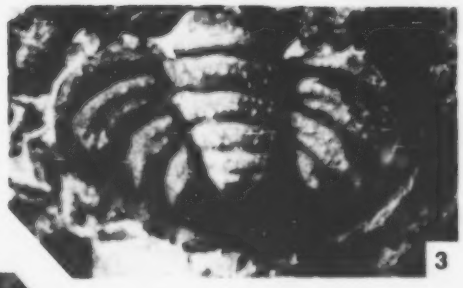
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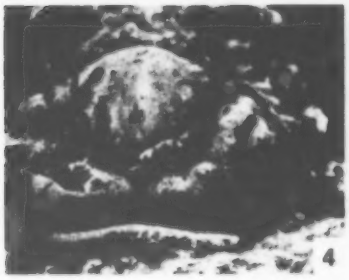
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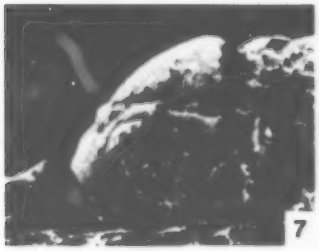
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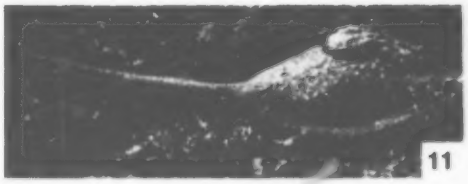
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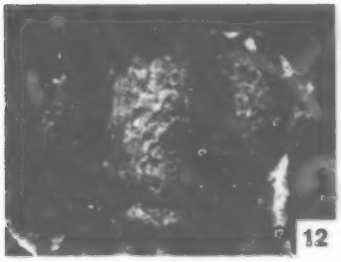
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PLATE 16

Figures 1, 2, 4-6. *Metabowmania* sp.

Survey Peak Formation, middle member

1, 2. Plan and anterior views of incomplete cranidium, GSC 62246, x 8; GSC loc. 92261.

5. Internal mould of fragmentary, small cranidium, GSC 62247, x 12; GSC loc. 92261.

Survey Peak Formation, upper massive member

4, 6. Anterior and plan views of internal mould of incomplete cranidium showing posterior border, GSC 62248, x 8; GSC loc. 92263.

Figures 3, 8. *Hillyardina* sp.

Survey Peak Formation, upper massive member

3. Incomplete left librigena, GSC 62249, x 6; GSC loc. 92263.

Survey Peak Formation, middle member

8. Partly exfoliated left librigena, GSC 62250, x 6; GSC loc. 92261.

Figures 7, 9, 10. *Hyperbolochilus* cf. *H. expansus* Kobayashi, 1955

Survey Peak Formation, middle member

Left lateral, anterior, and plan views of internal mould of incomplete cranidium, GSC 62251, x 6; GSC loc. 92253. See also Plate 17, figure 7.

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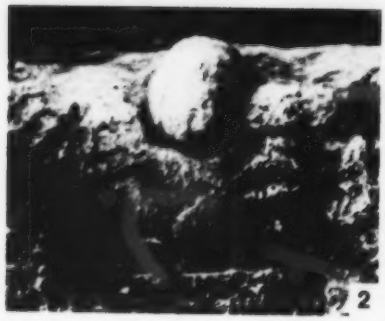
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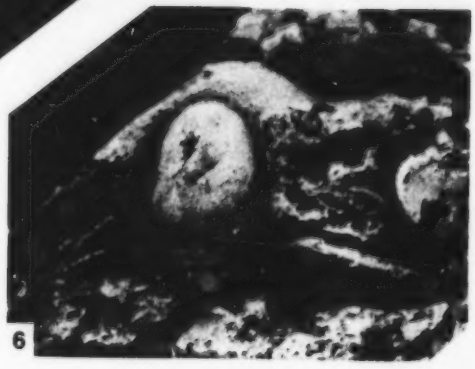
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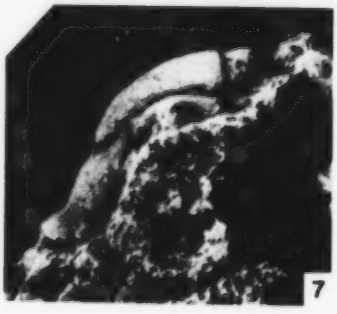
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PLATE 17

Figures 1, 3, 4, 6, 11. *Metabowmania latilimbata* Kobayashi, 1955

McKay Group, GSC loc. 7977, north of Brisco Trail, British Columbia.

1, 4, 11. Plan, anterior, and left lateral views of holotype cranidium, GSC 12713, x 6.

3, 6. Oblique left anterolateral and plan views of incomplete cranidium, GSC 12715, x 5. (Holotype of *Amechilus tuberculatus* Kobayashi, 1955, Pl. 6, fig. 11).

Figures 2, 5, 8. *Hyperbolochilus*? sp.

Survey Peak Formation, upper massive member

Anterior, plan, and left lateral views of damaged cranidium, GSC 62252, x 5; GSC loc. 92265.

Figure 7. *Hyperbolochilus* cf. *H. expansus* Kobayashi, 1955

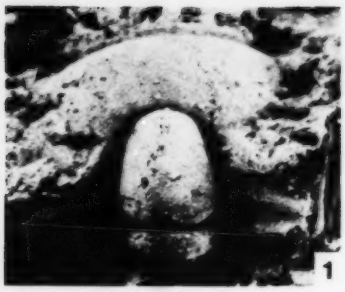
Survey Peak Formation, middle member

Latex cast of fragmentary cranidium, GSC 62251, x 6; GSC loc. 92253. See also Plate 16, figures 7, 9, 10.

Figures 9, 10, 12. *Hyperbolochilus expansus* Kobayashi, 1955

McKay Group, GSC loc. 7977, north of Brisco Trail, British Columbia.

Plan, right anterolateral, and anterior views of holotype cranidium, GSC 12636, x 5. (Figured by Kobayashi, 1955, Pl. 3, fig. 1).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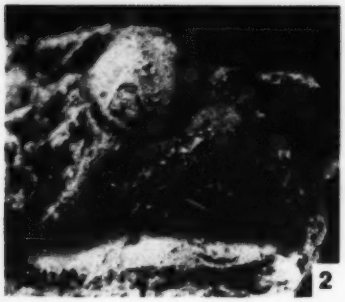
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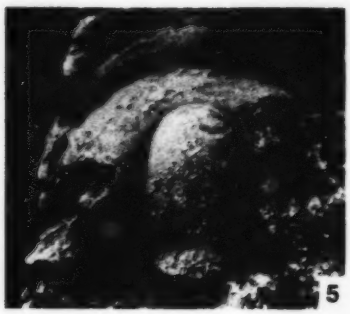
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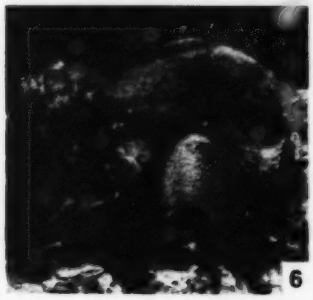
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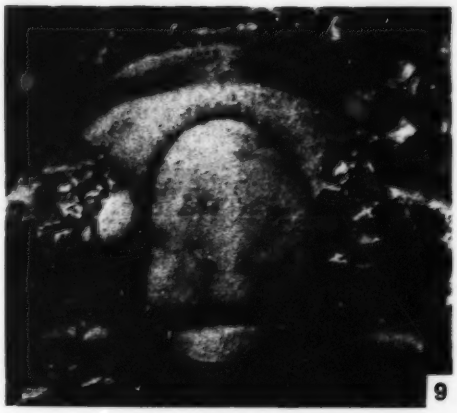
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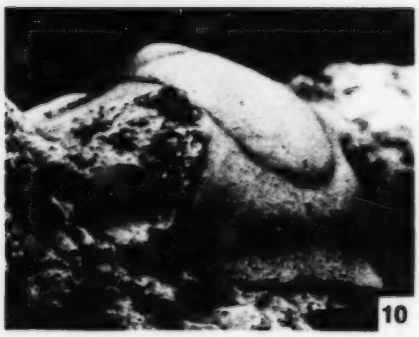
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PLATE 18

Figure 1. Gen. et sp. indet. E

Survey Peak Formation, middle member

Incomplete, partly exfoliated pygidium, GSC 62254, x 8; GSC loc. 92252.

Figures 2, 3, 5-7, 10. *Carolinites genacinaca* Ross, 1951

Outram Formation

2, 5. Right lateral and plan views of cranidium, GSC 62255, x 8; GSC loc. 92311.

Outram Formation

3, 6. Plan and anterior views of partly exfoliated cranidium, GSC 62256, x 8; GSC loc. 92324.

Skoki Formation

7, 10. Posterior and plan views of pygidium, GSC 62260, x 8; GSC loc. 92316.

Figures 4, 8, 9, 11, 12. *Carolinites* aff. *C. tasmaniensis* (Etheridge, 1919)

Outram Formation

4. Latex cast of incomplete cranidium, GSC 62257, x 8; GSC loc. 92275.

8, 11. Posterior and plan views of pygidium, GSC 62258, x 8; GSC loc. 92275.

9, 12. Oblique left lateral and plan views of incomplete cranidium, GSC 62259, x 6.5; GSC loc. 92275.

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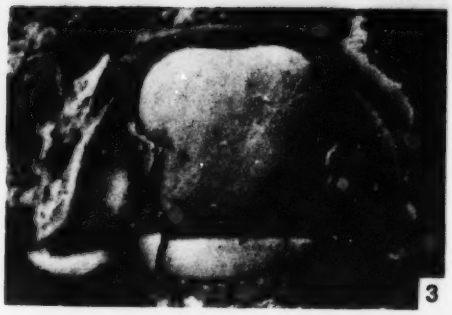
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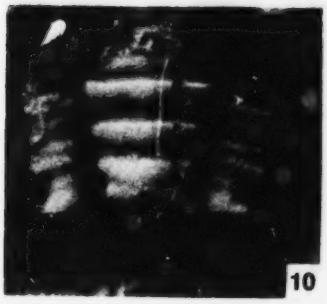
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PLATE 19

Figures 1-5, 7, 8. *Carolinites genacinaca* Ross, 1951

Skoki Formation

1, 2. Plan and oblique right lateral views of incomplete cranidium, GSC 62261, x 10; GSC loc. 92316.

3. Small cranidium, GSC 62262, x 12; GSC loc. 92316.

Outram Formation

4. Latex cast of front of same specimen as in Figure 5, x 8.

5. Partly exfoliated cranidium, GSC 62263, x 9; GSC loc. 92293.

7, 8. Plan and right lateral views of latex cast of right librigena showing holochroal surface of eye, GSC 62264, x 8; GSC loc. 92293.

Figures 6, 10. *Benthamaspis canadensis* n. sp.

Outram Formation

Left anterolateral and plan views of left librigena, paratype, GSC 62265, x 10; GSC loc. 92293.

Figures 9, 11. Gen. et sp. indet. F

Outram Formation

9. Left librigena showing visual surface of eye, GSC 62266, x 8; GSC loc. 92315.

11. Right librigena, GSC 62267, x 5; GSC loc. 92298.

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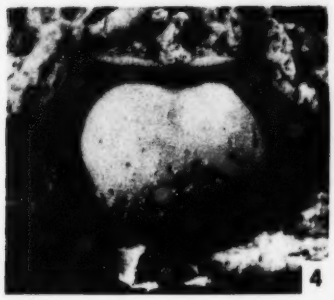
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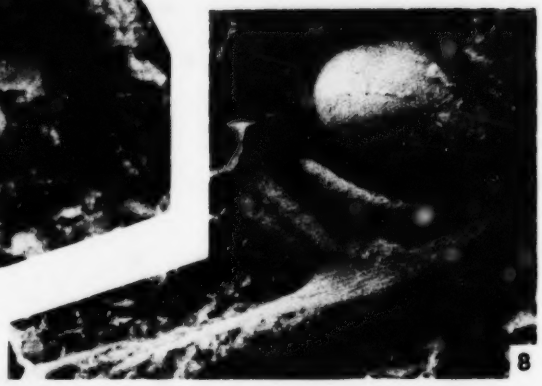
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PLATE 20

Figures 1-8. *Benthamaspis canadensis* n. sp.

Outram Formation

1. Plan view of partly exfoliated cranidium, paratype, GSC 62268, x 9.5; GSC loc. 92290.

2, 3, 6. Left lateral, anterior, and plan views of cranidium; note ornamentation, holotype, GSC 62269, x 10; GSC loc. 92290.

4. Latex cast of pygidium in figures 5, 7, 8, showing postaxial ridge.

5, 7, 8. Plan, left lateral, and posterior views of partly exfoliated pygidium, showing wide doublure and ornamentation of transverse ridges, paratype, GSC 62270, x 11; GSC loc. 92290.

Figures 9-13. *Benthamaspis diminutive* Hintze, 1953

Skoki Formation

9. Pygidium, GSC 62271, x 8; GSC loc. 92316.

10. Small pygidium with part of ornamentation preserved, GSC 62272, x 15; GSC loc. 92316.

11. Cranidium (note rim-like anterior border both here and in fig. 12), GSC 62273, x 12; GSC loc. 92316.

Outram Formation

12, 13. Anterior and plan views of damaged cranidium, GSC 62274, x 11; GSC loc. 92324.

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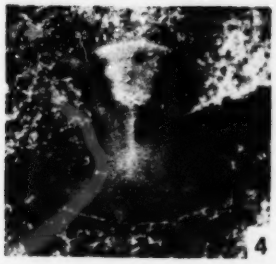
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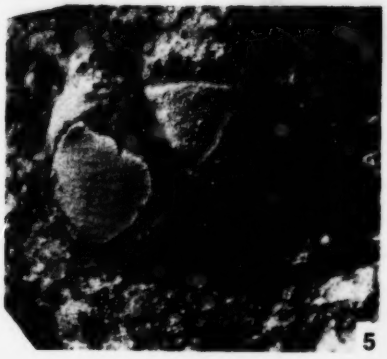
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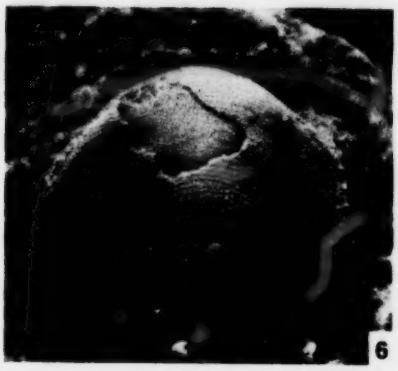
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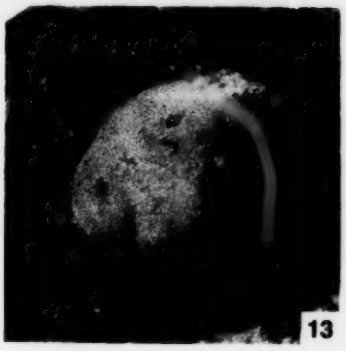
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PLATE 21

Figures 1-3, 5, 6, 8, 9, 11, 12. *Leiostegium* (*Evansaspis*) *ceratopygoides* (Raymond, 1925)

Survey Peak Formation, middle member

1, 5, 6. Right lateral, posterior, and plan views of large, incomplete pygidium, GSC 62276, x 3; GSC loc. 92252.

8. Exfoliated left librigena, GSC 62277, x 4; GSC loc. 92252.

Survey Peak Formation, upper massive member

2. Latex cast of part of cranidium showing oranmentation and anterior border, GSC 62278, x 7; GSC loc. 92263.

Survey Peak Formation, middle member

3. Incomplete pygidium showing pustulose ornamentation on axis and pleural regions, GSC 62279, x 5; GSC loc. 92257.

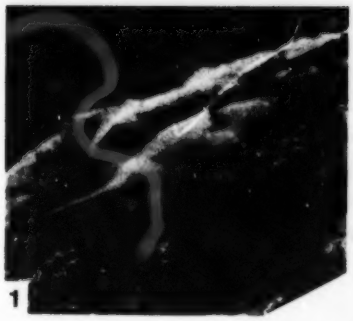
9, 12. Plan and posterior views of partly exfoliated pygidium showing doublure, GSC 62280, x 3; GSC loc. 92260.

11. Fragment of large pygidium showing smooth exoskeleton and posterolateral spine, GSC 62281, x 3.5; GSC loc. 92260.

Figures 4, 7, 10. *Leiostegium* (*Leiostegium*) *valmyense* (Lochman, 1966)

Survey Peak Formation, upper massive member

Left lateral, anterior, and plan views of cranidium, GSC 62275, x 5; GSC loc. 92267.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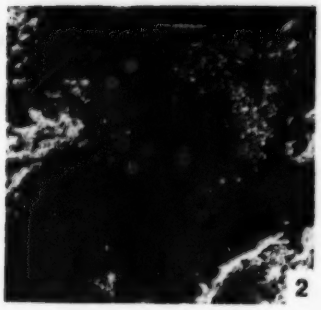
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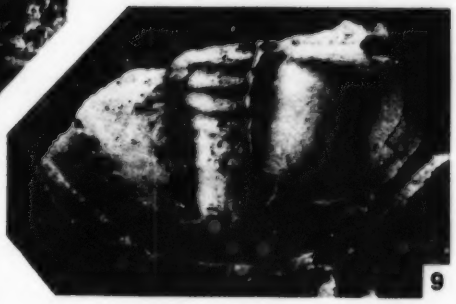
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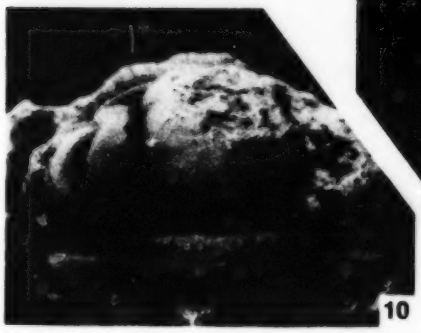
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PLATE 22

Figures 1, 2, 4, 6. *Leiostegium* (*Evansaspis*) *ceratopygoides* (Raymond, 1925)

McKay Group, GSC loc. 7977, north of Brisco Trail, British Columbia.

1. Pygidium, GSC 12629, x 11. (Holotype of *Leiostegium* (*Evansaspis*) *glabrum* Kobayashi, 1955, Pl. 2, fig. 11).

Survey Peak Formation, upper massive member

2. Small pygidium showing pustulose ornamentation, GSC 62282, x 8; GSC loc. 92263.

Survey Peak Formation, middle member

4. Large, smooth pygidium with posterolateral spines broken off, GSC 62283, x 3; GSC loc. 92252.

6. Small, coarsely pustulose pygidium, GSC 62284, x 12; GSC loc. 92260. Note that here and in figure 2 the posterolateral border spines are set relatively closer together than in large specimens.

Figures 3, 5, 7-13. *Kainella billingsi* (Walcott, 1924)

Survey Peak Formation, middle member

3. Small (?meraspid) cranidium, GSC 62296, x 10; GSC loc. 92241.

5. Small (?meraspid) cranidium, GSC 62297, x 10; GSC loc. 92241.

7. Latex cast of fragmentary cranidium, GSC 62301, x 6; GSC loc. 92240.

8. Cranidium with part of granulose exoskeleton intact, GSC 62298, x 6; GSC loc. 92241.

9, 11. Anterior and plan views of partly exfoliated cranidium, GSC 62303, x 4; GSC loc. 92245. (Note well developed caeca in front of glabella).

10. Incomplete cranidium, GSC 62299, x 4; GSC loc. 92241.

12. Almost exfoliated hypostoma, GSC 62300, x 7; GSC loc. 92241.

13. Internal mould of incomplete cranidium, GSC 62302, x 3.75; GSC loc. 92240.

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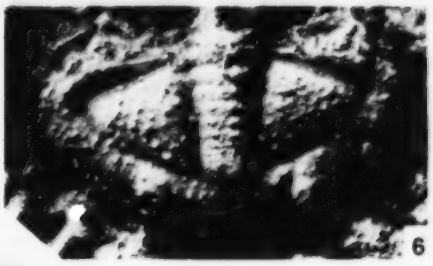
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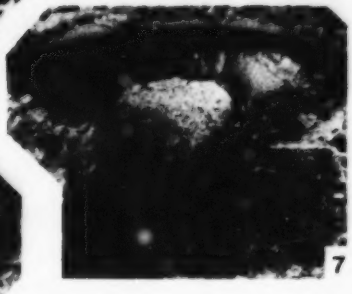
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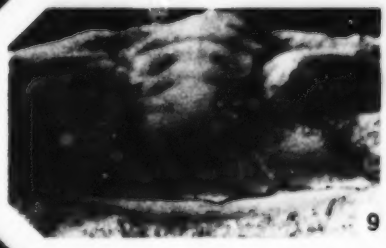
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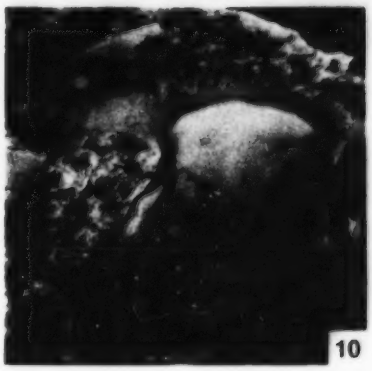
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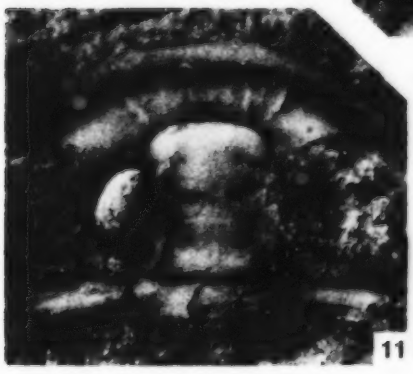
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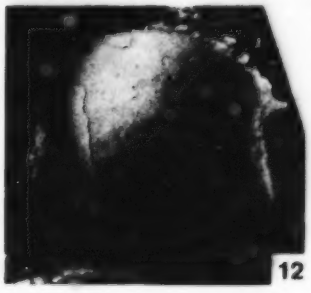
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PLATE 23

Figures 1-3, 5-13. *Kainella billingsi* (Walcott, 1924)

Survey Peak Formation, middle member

1. Latex cast of partly exfoliated left librigena showing doublure, GSC 62304, x 3; GSC loc. 92240.

2, 5, 9. Plan, posterior, and left lateral views of hypostoma, GSC 62306, x 8; GSC loc. 92241.

3. Latex cast of incomplete, right librigena, showing genal caeca and pitted surface, GSC 62307, x 2; GSC loc. 92245.

6. Latex cast of part of thoracic segment, GSC 62309, x 3; GSC loc. 92244.

7. Left librigena and small cranidium, GSC 62310, x 4; GSC loc. 92244.

8, 10, 11. Posterior, right lateral, and plan views of pygidium, GSC 62305, x 4.5; GSC 92240.

12, 13. Latex cast and internal mould of pygidium, GSC 62311, x 4; GSC loc. 92242.

Figure 4. *Kainella flagricauda* (White, 1874)

Survey Peak Formation, middle member

Small pygidium, GSC 62308, x 5; GSC loc. 92245.

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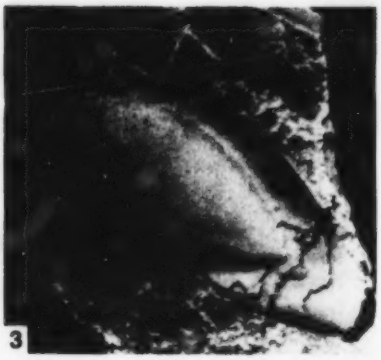
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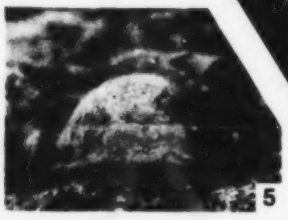
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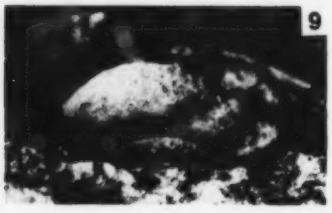
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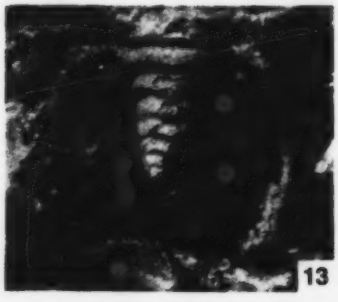
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PLATE 24

Figures 1, 2, 4, 7. *Apatokephalus? longifrons* n. sp.

Survey Peak Formation, middle member

1, 2, 4. Anterior, plan, and right lateral views of cranidium, holotype, GSC 62291, x 9; GSC loc. 92241.

7. Small cranidium, paratype, GSC 62292, x 11; GSC loc. 92241.

Figures 3, 5, 8. *Apatokephalus* sp.

Outram Formation

3. Partly exfoliated, incomplete cranidium; GSC 62293, x 6; GSC loc. 92270.

Survey Peak Formation, upper massive member

5. Latex cast of incomplete cranidium, GSC 62294, x 10; GSC loc. 92267.

Outram Formation

8. External mould of ventral surface of pygidial doublure, GSC 62295, x 10; GSC loc. 92283.

Figures, 6, 9. *Apatokephalus canadensis* Kobayashi, 1953

McKay Group, north of Brisco Trail, British Columbia.

6. Paratype, pygidium, GSC 11927, x 6. (Figured by Kobayashi, 1953, Pl. 3, fig. 2).

9. Holotype, cranidium, GSC 11926, x 7. (Figured by Kobayashi, 1953, Pl. 3, fig. 1).

Figures 10-15. *Apatokephaloides clivosus* Raymond, 1924

Survey Peak Formation, basal silty member

10. Latex cast of fragment of cranidium, GSC 62285, x 10; GSC loc. 92206.

11. Internal mould of cranidium, GSC 62286, x 10; GSC loc. 92206.

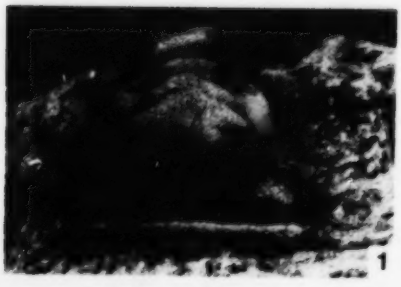
12. Internal mould of front of cranidium, GSC 62287, x 10; GSC loc. 92206.

13. Latex cast of left librigena, GSC 62288, x 10; GSC loc. 92206.

Survey Peak Formation, basal silty member

14. Latex cast of part of right librigena, GSC 62289, x 10; GSC loc. 92207.

15. Internal mould of part of right librigena, GSC 62290, x 5.5; GSC loc. 92207.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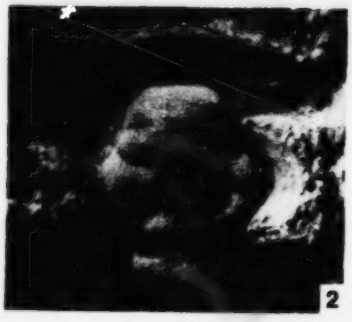
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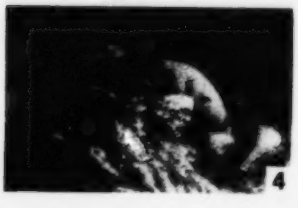
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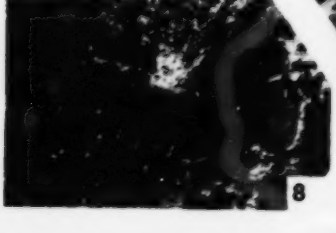
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PLATE 25

Figures 1-11. *Menoparia elegans* n. sp.

All from Outram Formation, GSC loc. 92276.

1, 3, 7. Plan, anterior, and right lateral views of holotype cranidium, GSC 62312, x 4.5.

2. Close-up of anterior border of holotype cranidium, x 8.

11. Close-up of right palpebral lobe and part of occipital ring and glabella, x 8.

4. Right librigena, paratype, GSC 62313, x 3.5.

5. Incomplete cranidium, paratype, GSC 62314, x 6.

6. Meraspid(?) cranidium, paratype, GSC 62315, x 12.

8-10. Plan, posterior, and oblique left lateral views of latex cast of pygidium, paratype, GSC 62316, x 6.

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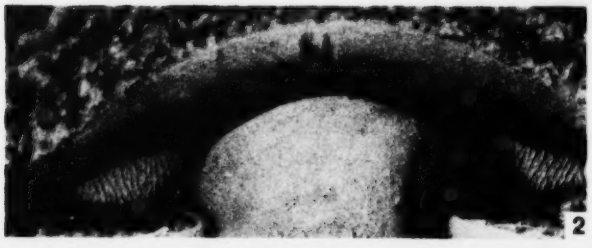
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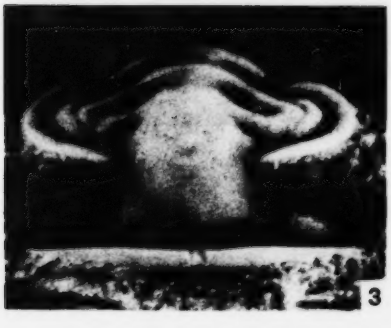
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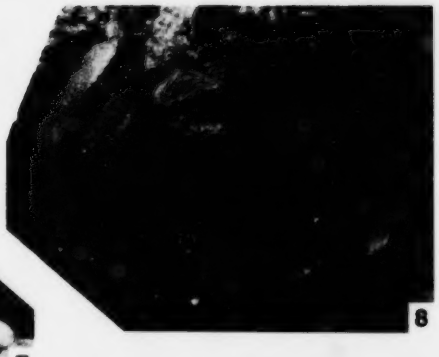
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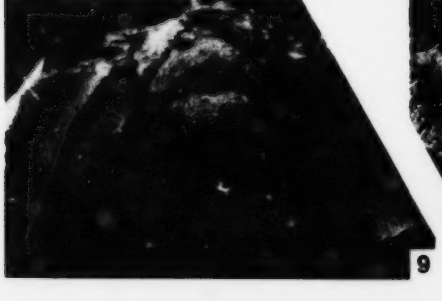
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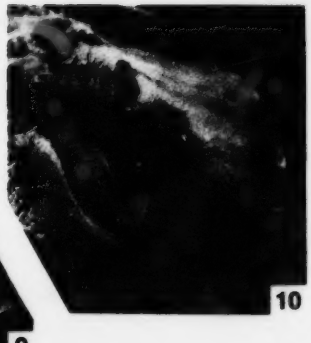
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PLATE 26

Figures 1-14. *Goniotelina brevis* (Hintze, 1953)

Outram Formation

1, 4. Anterior and plan views of small, fragmentary cranidium, GSC 62317, x 8; GSC loc. 92298.

2, 3. Anterior and plan views of damaged cranidium, GSC 62318, x 5; GSC 92314.

6. Incomplete cranidium, GSC 62321, x 5; GSC loc. 92324.

8. Latex cast of incomplete cranidium, GSC 62323, x 8; GSC loc. 92321.

9. Incomplete, almost exfoliated cranidium, GSC 62324, x 5; GSC loc. 92323.

10. Latex cast of incomplete hypostoma, GSC 62326, x 7; GSC loc. 92315.

11. Incomplete left librigena, GSC 62327, x 5; GSC loc. 92309.

12, 14. Right lateral and plan views of pygidium, GSC 62325, x 5; GSC loc. 92323.

13. Internal mould of small cranidium showing pustulose ornamentation interrupted by smooth areas representing muscle scars, GSC 62322, x 8; GSC loc. 92324.

Skoki Formation

5. Incomplete pygidium, GSC 62319, x 12; GSC loc. 92316.

7. Left librigena, GSC 62320, x 7; GSC loc. 92316.

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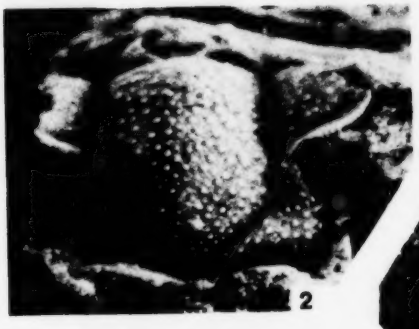
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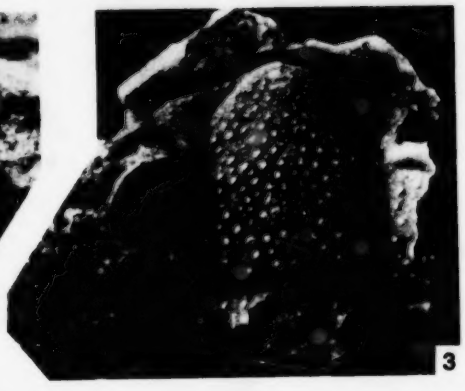
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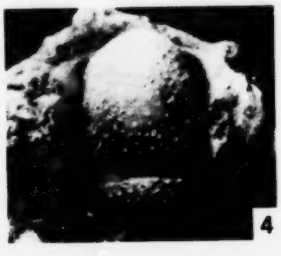
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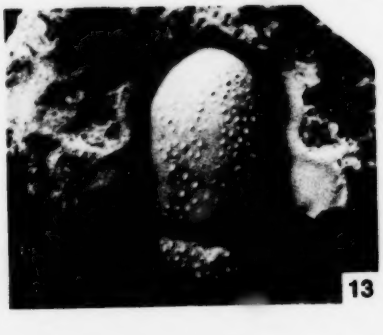
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PLATE 27

Figures 1-3. *Goniotelina brevis* (Hintze, 1953)

Outram Formation

Posterior, left lateral, and plan views of incomplete pygidium, GSC 62328, x 7; GSC loc. 92315.

Figures 4-6. *Gonioteloides monoceros* Kobayashi, 1955

McKay Group, GSC loc. 7977, north of Brisco Trail, British Columbia.

4, 5. Left posterolateral and plan views of holotype pygidium, GSC 12697, x 4. (Figured by Kobayashi, 1955, Pl. 6, fig. 17a, b).

Survey Peak Formation, middle member

6. Latex cast of fragment of pygidium, GSC 62331, x 2.5; GSC loc. 92256.

Figures 7, 9, 12, 14. *Benthamaspis obrepta* (Lochman, 1966)

Outram Formation

7, 9, 12. Plan, right lateral and anterior views of cranidium, GSC 62332, x 10; GSC loc. 92281.

14. Front of same specimen enlarged to show ridge-like anterior border and narrow palpebral lobes, x 13.

Figures 8, 10, 11, 13. *Goniotelina*? sp.

Outram Formation

8, 10, 11. Anterior, left lateral, and plan views of incomplete internal mould of cranidium, GSC 62329, x 4; GSC loc. 92321.

13. Latex cast of fragment of counterpart external mould, x 4.

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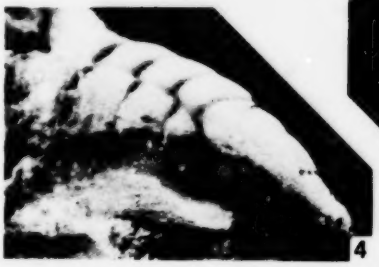
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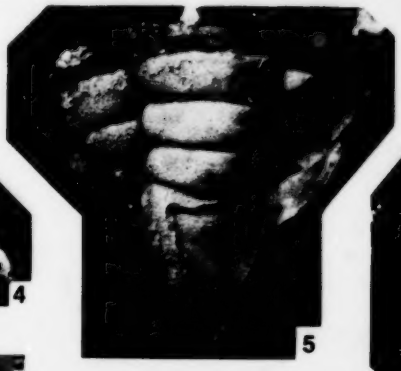
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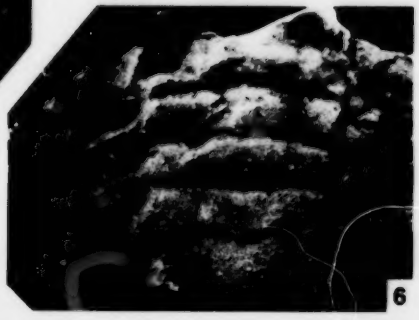
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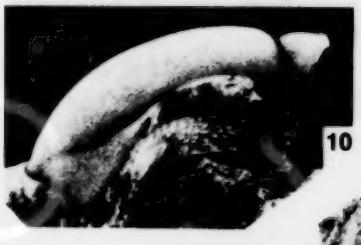
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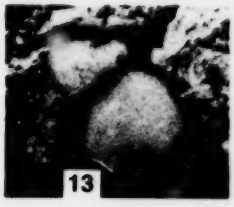
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PLATE 28

Figures 1-3, 5, 6. *Ischyrotoma* cf. *I. eos* (Kobayashi, 1955)

Survey Peak Formation, middle member

1. Partly exfoliated pygidium, GSC 62335, x 5; GSC loc. 92252.

2. Partly exfoliated pygidium, GSC 62336, x 5; GSC loc. 92253.

3, 5, 6. Posterior, left lateral, and plan views of incomplete pygidium, GSC 62337, x 5; GSC loc. 92256.

Figures 4, 8. *Pseudoclelandia cornupsittaca* Ross, 1951

Survey Peak Formation, upper massive member

Plan and anterior views of incomplete cranidium, GSC 62338, x 12; GSC loc. 92265.

Figures 11, 12, 14. *Pseudoclelandia fluxafissura* Ross, 1951

Survey Peak Formation, middle member

Anterior, left lateral, and plan views of cranidium, GSC 62339, x 9; GSC loc. 92258.

Figures 7, 9, 10, 13, 15-17. *Ischyrotoma* cf. *I. caudanodosa* (Ross, 1951)

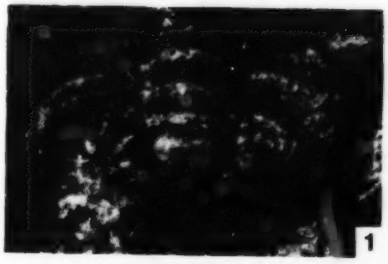
Skoki Formation

7, 9, 10. Left lateral, anterior, and plan views of cephalon with librigenae in place, GSC 62182, x 12; GSC loc. 92316.

13, 15, 17. Anterior, left lateral, and plan views of incomplete cranidium, GSC 62333, x 16, x 15, x 15, respectively; GSC loc. 92316.

Outram Formation

16. Latex cast of right librigena showing small, thorn-like librigenal spine, GSC 62334, x 13; GSC loc. 92313.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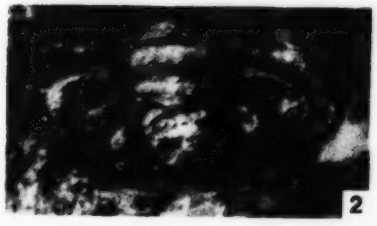
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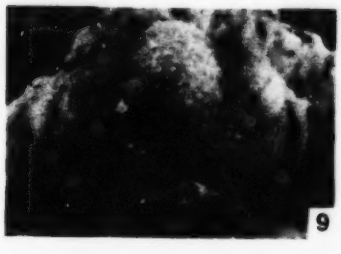
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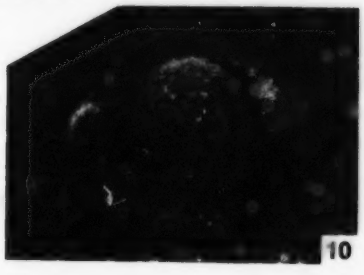
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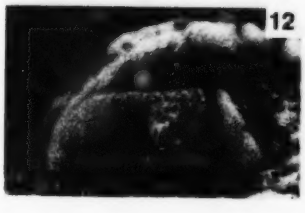
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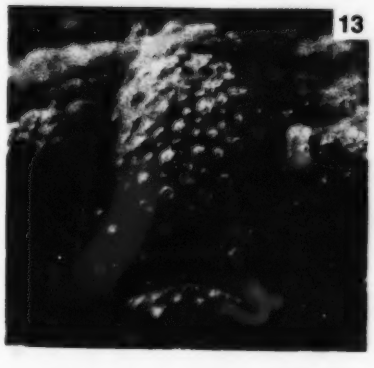
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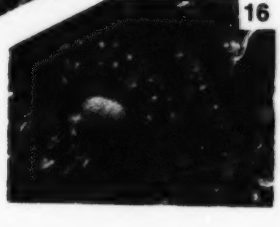
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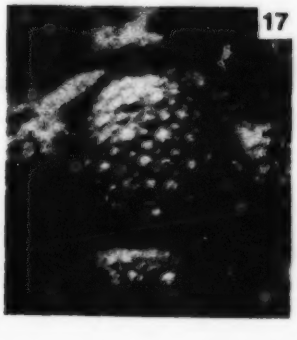
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PLATE 29

Figures 1-10, 12, 13, 15. *Clelandia albertensis* Norford, 1969

Survey Peak Formation, basal silty member

1, 2, 5, 6. Plan, left lateral, oblique left lateral, and anterior views of cranidium, GSC 62340, x 8; GSC loc. 92232.

3. Fragmentary cranidium, GSC 62341, x 12; GSC loc. 92231.

4, 7. Oblique left lateral and plan views of cranidium, GSC 62342, x 15; GSC loc. 92226.

8, 9, 13. Anterior, left lateral, and plan views of cranidium, GSC 62343, x 8; GSC loc. 89267.

10. Small cranidium, GSC 62344, x 15; GSC loc. 89295.

15. Cranidium, GSC 62349, x 15; GSC loc. 92228.

Survey Peak Formation, putty shale member

12. Latex cast of incomplete cranidium, GSC 62348, x 12; GSC loc. 89282.

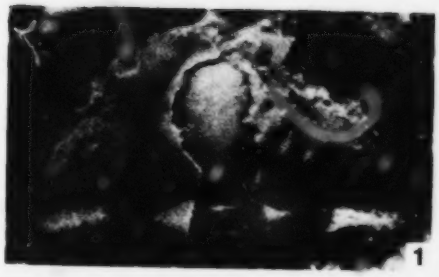
Figures 11, 14, 16. *Clelandia* sp.

Survey Peak Formation, basal silty member

11. Cranidium, GSC 62345, x 12; GSC loc. 89293.

14. Latex cast of incomplete cranidium, GSC 62346, x 10; GSC loc. 89293.

16. Partly exfoliated, fragmentary cranidium, GSC 62347, x 7; GSC loc. 89293.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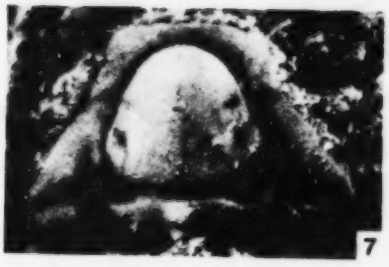
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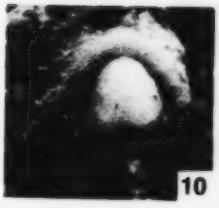
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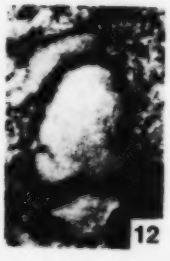
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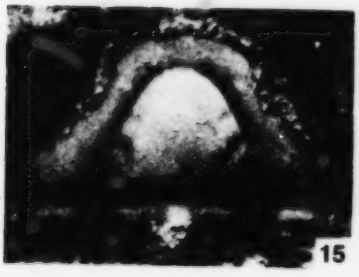
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PLATE 30

Figures 1-12. *Aulacoparia* (*Aulacoparia*) *sculpta* n. sp.

Outram Formation

1-3. Plan, anterior, and right lateral views of cranidium, paratype, GSC 62351, x 6; GSC loc. 92276.

4, 5, 7. Posterior, right lateral, and plan views of pygidium, holotype, GSC 62350, x 6; GSC loc. 92276.

6, 11. Plan and left anterolateral views of latex cast of incomplete cranidium, paratype, GSC 62352, x 5, x 7, respectively; GSC loc. 92276.

8. Small right librigena, paratype, GSC 62354, x 7; GSC loc. 92278.

9. Cranidium, paratype, GSC 62353, x 10; GSC loc. 92276.

10. Small cranidium, paratype, GSC 62355, x 8; GSC loc. 92279.

12. Incomplete cranidium showing deep 1p glabellar furrows and swollen occipital lobes, paratype, GSC 62356, x 8; GSC loc. 92281.

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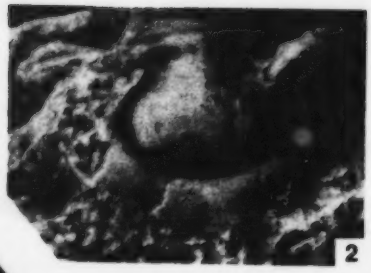
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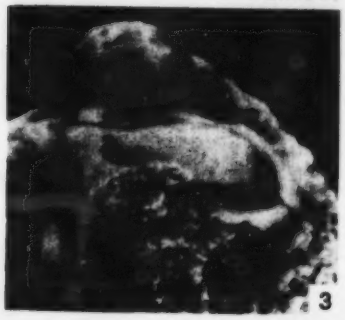
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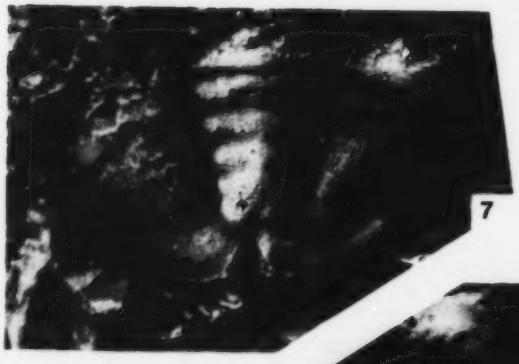
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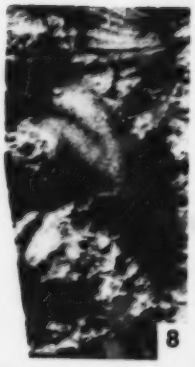
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PLATE 31

Figures 1-6, 9. *Aulacoparia* (*Aulacoparia*) *sculpta* n. sp.

Outram Formation

1. Pygidium, paratype, GSC 62357, x 9; GSC loc. 92279.
2. Small pygidium, paratype, GSC 62358, x 10; GSC loc. 92279.
3. Incomplete cranidium, paratype, GSC 62359, x 6; GSC loc. 92273.
4. Fragmentary pygidium, paratype, GSC 62360, x 5; GSC loc. 92273.
5. Latex cast of pygidium, paratype, GSC 62361, x 5; GSC loc. 92273.
6. Small pygidium, paratype, GSC 62362, x 10; GSC loc. 92274.
9. Internal mould of hypostoma, paratype, GSC 62363, x 7; GSC loc. 92273.

Figures 7, 8, 10-15. *Isoteloides saxosimontis* n. sp.

Outram Formation

7. Left librigena showing pitting of test, paratype, GSC 62364, x 5; GSC loc. 92310.
10. Exfoliated right librigena, paratype, GSC 62365, x 5; GSC loc. 92310.
13. Partly exfoliated cranidium, paratype, GSC 62366, x 3; GSC loc. 92310.

8, 12. Internal mould and latex cast of incomplete cranidium, holotype, GSC 62367, x 3; GSC loc. 92309.

11, 14, 15. Anterior, right lateral, and plan views of cranidium, paratype, GSC 62368, x 3.5; GSC loc. 92309.

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PLATE 32

Figures 1-9. *Isoteloides saxosimontis* n. sp.

Outram Formation

1, 2. Partly exfoliated cranidium and latex cast of counterpart, paratype, GSC 62369, x 4; GSC loc. 92322.

3. Internal mould of fragmentary pygidium, paratype, GSC 62372, x 2.5; GSC loc. 92310.

4. Internal mould of incomplete pygidium, paratype, GSC 62370, x 4.5; GSC loc. 92322.

5. Internal mould of pygidium, paratype, GSC 62374, x 3.5; GSC loc. 92309.

6. Almost exfoliated pygidium, paratype, GSC 62373; x 4; GSC loc. 92310.

7, 9. Plan and right posterolateral views of small pygidium, paratype, GSC 62375, x 6; GSC loc. 92309.

8. Internal mould of pygidium, paratype, GSC 62371, x 5; GSC loc. 92322.

Figures 10-15. *Lachnostoma latucelsum* Ross, 1951

Outram Formation

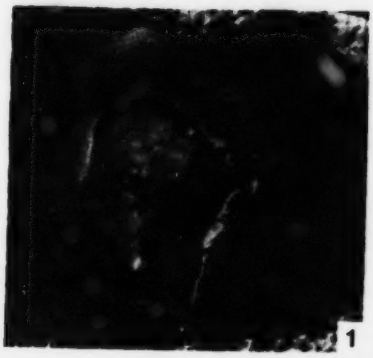
10. Latex cast of incomplete small cranidium, GSC 62376, x 6; GSC loc. 92293.

11, 12. Plan and left anterolateral views of cranidium, GSC 62377, x 3; GSC loc. 92300.

13. Exfoliated cranidium showing low, longitudinal ridge in front of median tubercle, GSC 62378, x 4.5; GSC loc. 92296.

14. Cranidium lacking palpebral lobes, GSC 62379, x 4; GSC loc. 92287.

15. Latex cast of incomplete cranidium associated with pygidium of *P. (Presbynileus) latifrons*, GSC 62380, x 2.5; GSC loc. 92298.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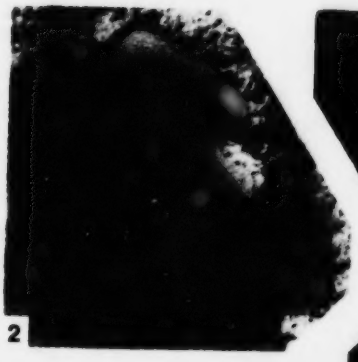
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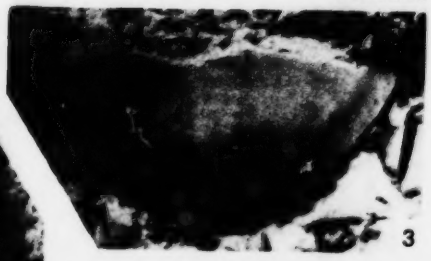
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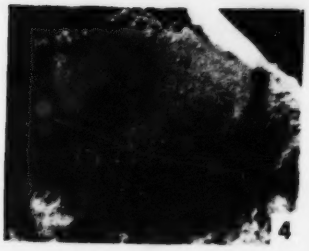
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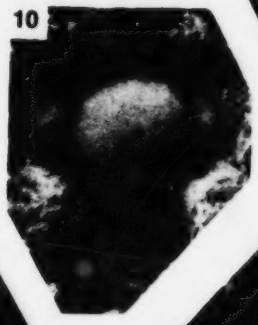
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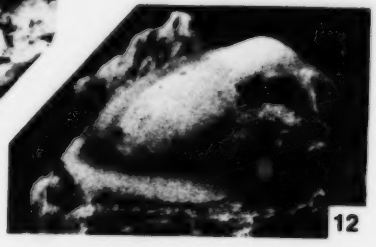
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PLATE 33

Figures 1-16. *Lachnostoma latucelsum* Ross, 1951

Outram Formation

1. Latex cast of cranidium, GSC 62381, x 3; GSC loc. 92301.

2. Internal mould of small cranidium, GSC 62383, x 6; GSC loc. 92310.

3, 5, 6. Plan, posterior, and right lateral views of partly exfoliated pygidium, GSC 62385, x 4.5; GSC loc. 92293.

4. Exfoliated pygidium showing doublure, GSC 62386, x 4; GSC loc. 92296.

7. Partly exfoliated pygidium (note development of ring furrows), GSC 62387, x 2; GSC loc. 92297.

8. Small cranidium showing eye ridges and median preglabellar ridge, GSC 62382, x 8; GSC loc. 92301.

9. Small pygidium showing wide border, GSC 62390, x 7; GSC loc. 92287.

10. Partly exfoliated pygidium, GSC 62388, x 4; GSC loc. 92297.

11. Doublure of partly exfoliated pygidium, GSC 62391, x 5; GSC loc. 92303.

12. Latex cast of fragmentary pygidium, GSC 62392, x 3; GSC loc. 92298.

13. Small pygidium, GSC 62384, x 8; GSC loc. 92310.

14. Plan view of same specimen as in figure 11, x 3.

15. Partly exfoliated pygidium, GSC 62389, x 3.5; GSC loc. 92297.

16. Fragment of slightly compressed, exfoliated pygidium showing ring furrows and traces of pleural and interpleural furrows, GSC 62212, x 4; GSC loc. 92305.

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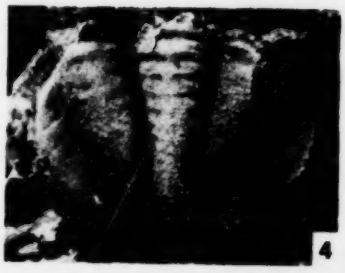
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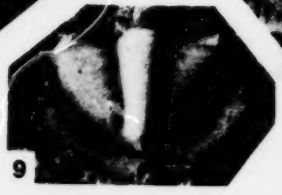
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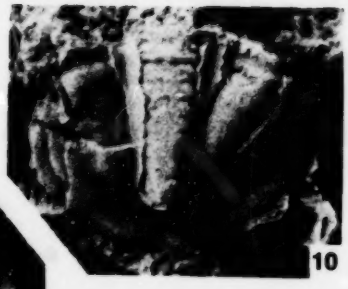
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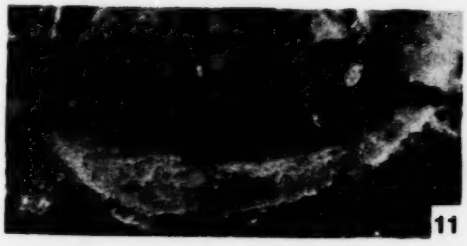
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PLATE 34

Figures 1-4, 6, 7, 9-13. *Presbynileus* (*Presbynileus*) *latifrons* n. sp.

Outram Formation

1. Internal mould of glabella showing median tubercle and lobation of glabella, paratype, GSC 62394, x 3; GSC 92293.

2. Latex cast showing ornamentation of glabella, paratype, GSC 62395, x 4; GSC loc. 92301.

3. Internal mould of cranidium, paratype, GSC 62396, x 4; GSC loc. 92303.

4. Internal mould of cranidium, paratype, GSC 62397, x 3; GSC loc. 92298.

6, 9. Anterior and plan views of large cranidium (note flat top of palpebral lobes), holotype, GSC 62393, x 2.5; GSC loc. 92298.

Skoki Formation

7. Exfoliated, small left librigena, paratype, GSC 62399, x 6; GSC loc. 92316.

Outram Formation

10. Ventral side of pygidial doublure with panderian protuberance and opening, paratype, GSC 62400, x 2.5; GSC loc. 92291.

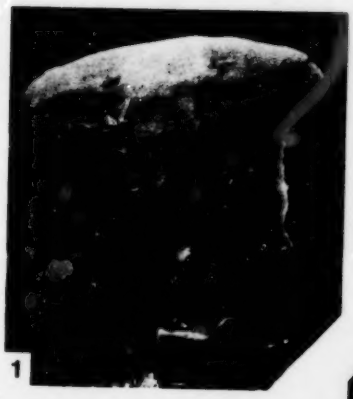
11, 12. Internal mould and latex cast of right librigena (note impression of panderian protuberance), paratype, GSC 62401, x 4; GSC loc. 92285.

13. Internal mould of small pygidium, paratype, GSC 62402, x 3; GSC loc. 92297.

Figures 5, 8. *Presbynileus* (*Presbynileus*) sp.

Outram Formation

Plan and anterior views of latex cast of incomplete cranidium, GSC 62398; x 4; GSC loc. 92320.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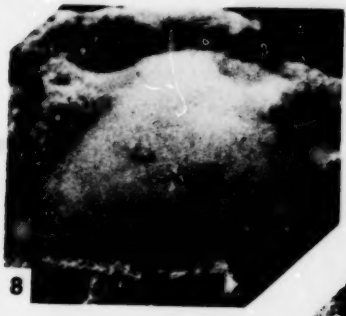
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PLATE 35

Figures 1-11. *Presbynileus* (*Presbynileus*) *latifrons* n. sp.

Outram Formation

1, 4. Posterior and plan views of pygidium, showing doublure, paratype, GSC 62403, x 3; GSC loc. 92298.

2, 3, 6. Right lateral, posterior, and plan views of pygidium, paratype, GSC 62406, x 2; GSC loc. 92297.

5. Large pygidium, paratype, GSC 62404, x 1.75; GSC loc. 92298.

7. Small pygidium, paratype, GSC 62405, x 5; GSC loc. 92298.

8. Exfoliated pygidium, paratype, GSC 62407, x 2.5; GSC loc. 92301.

9. Incomplete pygidium, paratype, GSC 62408, x 3; GSC loc. 92302.

Skoki Formation

10. Large pygidium, paratype, GSC 62409, x 2; GSC loc. 92316.

Outram Formation

11. Exfoliated pygidium showing part of doublure, paratype, GSC 62410, x 4; GSC loc. 92303.

Figures 12-15. *Ptyocephalus declevitus* (Ross, 1951)

Outram Formation

12. Small cranidium, GSC 62411, x 9; GSC loc. 92312.

13, 14. Plan and right lateral views of incomplete cranidium, GSC 62412, x 5; GSC loc. 92310.

15. Cranidium, GSC 62413, x 8; GSC loc. 92309.

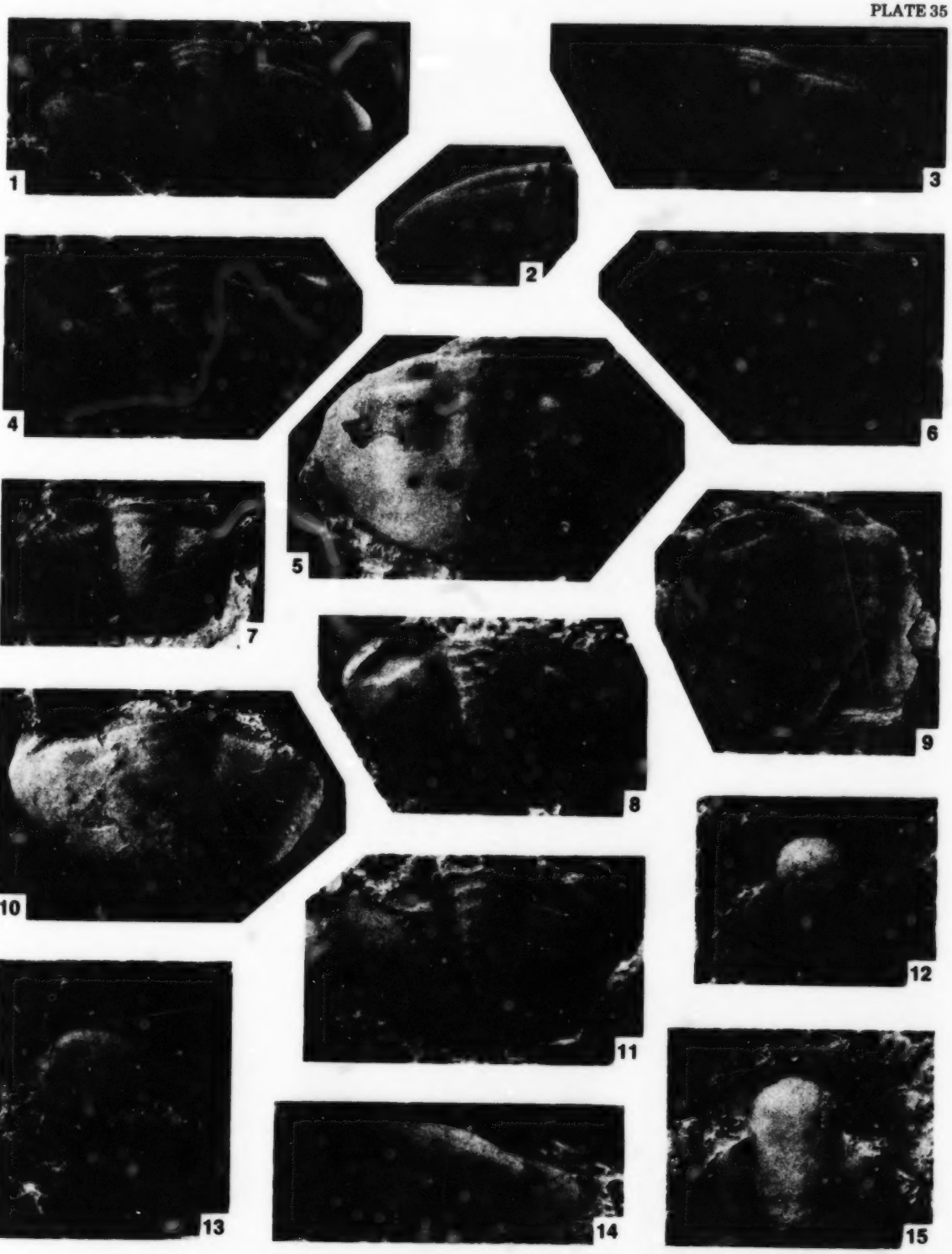
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PLATE 36

Figures 1-4, 6-13. *Ptyocephalus declevitus* (Ross, 1951)

Outram Formation

1. Left librigena viewed perpendicular to surface, GSC 62414, x 3.5; GSC loc. 92298.

2, 3. Plan and left lateral views of pygidium, GSC 62415, x 7; GSC loc. 92309.

Skoki Formation

4, 7. Oblique right lateral and plan views of latex cast of pygidium, GSC 62416, x 7, x 5, respectively; GSC loc. 92316.

6. Partly exfoliated cranidium, GSC 62419, x 4; GSC loc. 92323.

8. Cranidium, GSC 62420, x 5; GSC loc. 92324.

9. Cranidium, GSC 62417, x 8; GSC loc. 92316.

10. Poorly-preserved cranidium (here and in figure 9 the small, median glabellar tubercle is visible), GSC 62422, x 4; GSC loc. 92317.

11, 12. Oblique right lateral and plan views of internal mould of same specimen as in figures 4 and 7, showing doublure, x 5.

13. Pygidium, GSC 62421, x 5; GSC loc. 92324.

Figure 5. *Ptyocephalus acclivus* (Hintze, 1953)

Outram Formation

Incomplete pygidium, GSC 62418, x 5; GSC loc. 92289.

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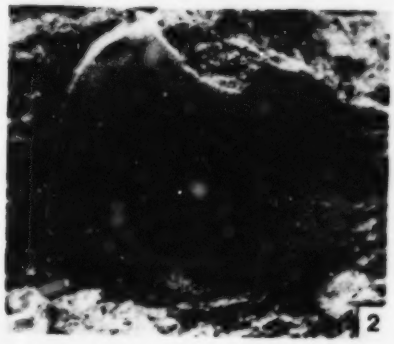
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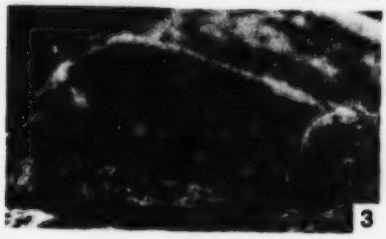
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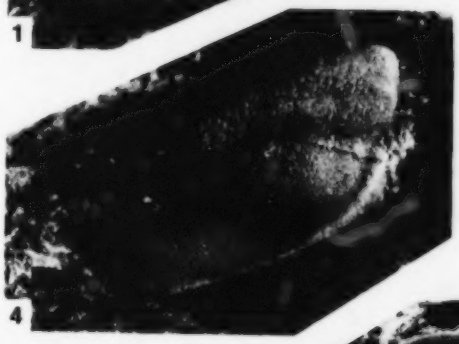
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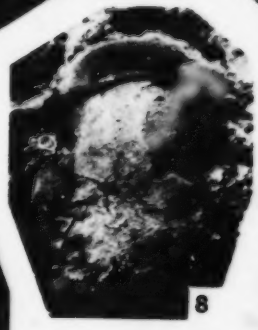
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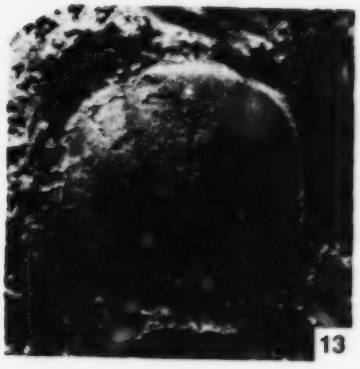
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PLATE 37

Figures 1, 4. Asaphid hypostoma A

Outram Formation

Incomplete latex cast (x 5) and internal mould (x 6), GSC 62424; GSC loc. 92319.

Figures 2, 3, 13. Asaphid hypostoma B

Outram Formation

2, 3. Internal mould and latex cast, GSC 62425, x 7; GSC loc. 92288.

13. Internal mould, GSC 62427, x 6; GSC loc. 92276.

Figure 5. Asaphid hypostoma C

Outram Formation

Small hypostoma, GSC 62426, x 12; GSC loc. 92276.

Figures 6, 11, 12. *Ptyocephalus declevitus* (Ross, 1951)

Skoki Formation

6. Part of hypostoma showing ornamentation, GSC 62428, x 5; GSC loc. 92316.

11. Hypostoma with notched posterior margin preserved, GSC 62429, x 6; GSC loc. 92316.

Outram Formation

12. Hypostoma, GSC 62432, x 9; GSC loc. 92321.

Figure 7. Asaphid hypostoma D

Outram Formation

Latex cast, GSC 62430, x 2; GSC loc. 92300.

Figures 8-10. Asaphid hypostoma E

Outram Formation

Right lateral, anterior, and plan views, GSC 62431, x 5; GSC loc. 92301.

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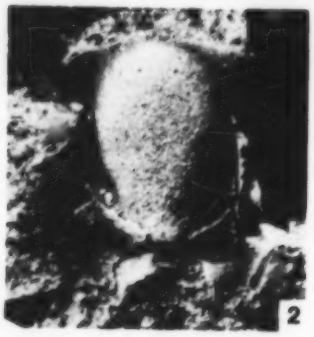
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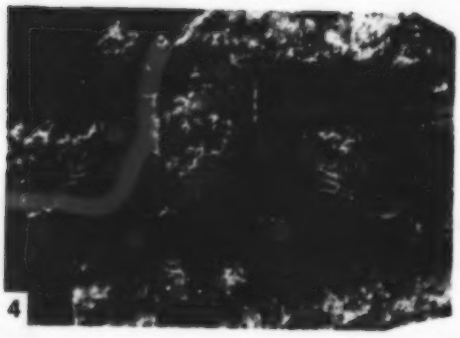
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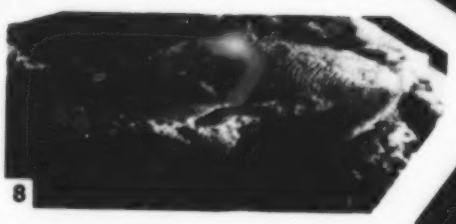
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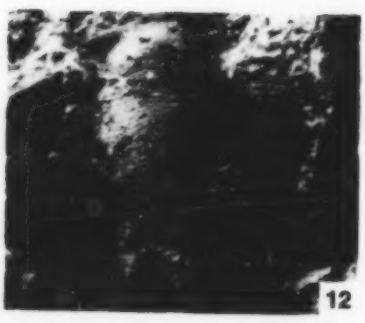
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PLATE 38

Figures 1-13. *Symphysurina walcotti* Kindle, 1929

Survey Peak Formation, basal silty member

1. Exfoliated cranidium showing palpebral lobes and trace of paired muscle impressions, GSC 62433, x 6; GSC loc. 92227.

2. Internal mould of part of glabella, showing paired muscle impressions, GSC 62441, x 3; GSC loc. 89295.

3. Latex cast of incomplete, partly exfoliated cranidium showing median ridge and paired muscle impressions, GSC 62435, x 5; GSC loc. 92226.

4. Partly exfoliated cranidium, showing median tubercle, GSC 62436, x 7; GSC loc. 92226.

5. Incomplete, largely exfoliated cranidium, showing median tubercle, sagittal ridge, and right anterior branch of facial suture, GSC 62442, x 4; GSC loc. 89281.

6. Incomplete internal mould of cranidium, GSC 62438, x 6; GSC loc. 92228.

7. Latex cast of pygidium, GSC 85700, x 7; GSC loc. 92231.

8. Posterior view of largely exfoliated pygidium, showing part of narrow doublure, GSC 62439, x 5; GSC loc. 92228.

9. Small pygidium, GSC 62443, x 5; GSC loc. 89294.

10. Pygidium with most of test preserved. Exfoliated portion shows stronger development of first pleural furrow on internal mould, GSC 62434, x 5; GSC loc. 92227.

11. Pygidium with associated cranidium of *Highgatella? cordilleri*, GSC 62440, x 4; GSC loc. 89275.

12. Pygidium with test preserved, GSC 62437, x 6; GSC loc. 92226.

Unnamed Formation of "Ozarkian" age, Swift's Ranch, 11.2 km (7 mi) north of Jasper, Alberta.

13. Holotype pygidium, GSC 9378, x 5.5. (Figured by Kindle, 1929, Pl. 1, fig. 18).

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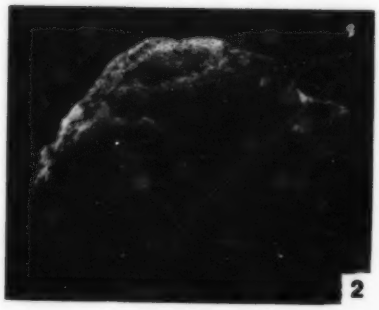
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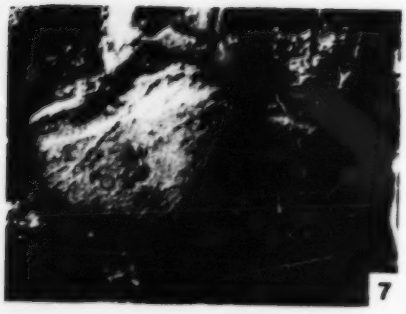
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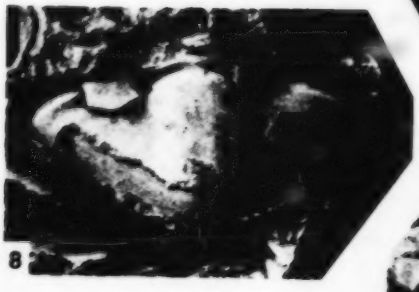
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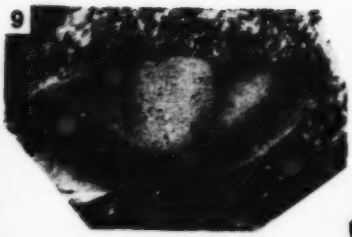
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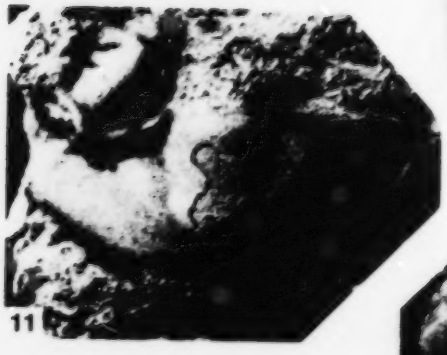
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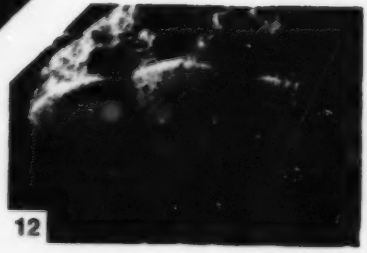
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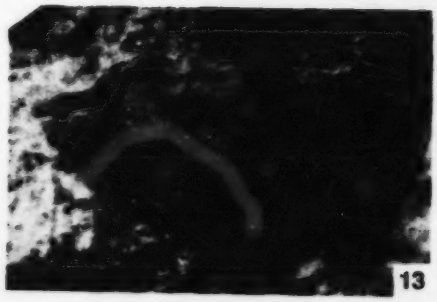
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PLATE 39

Figures 1, 3, 4, 7-9, 11, 12. *Symphysurina spicata* Ulrich in Walcott, 1925

Survey Peak Formation, putty shale member

1. Latex cast of pygidium, GSC 62444, x 4; GSC loc. 89282.

7, 9. Plan and posterior views of pygidium with broken spine, GSC 62448, x 4; GSC loc. 89282.

Survey Peak Formation, basal silty member

3. Left librigena, GSC 62449, x 5; GSC loc. 92225.

4. Latex cast of almost exfoliated pygidium, GSC 62446, x 7; GSC loc. 89293.

8. Incomplete pygidium with part of terminal spine preserved, GSC 62451, x 6; GSC loc. 92228.

11. Latex cast of pygidium with short terminal spine, GSC 62453, x 7; GSC loc. 89272.

12. Latex cast of small pygidium, GSC 62454, x 6; GSC loc. 92222.

Figures 2, 5, 10, 13. *Symphysurina* sp.

Survey Peak Formation, basal silty member

2. Slightly compressed, almost exfoliated pygidium showing tip of axis and base of spine, GSC 62445, x 3; GSC loc. 89293.

Survey Peak Formation, putty shale member

5. Amost complete pygidium, GSC 62447, x 4; GSC loc. 89288.

10. Partly exfoliated pygidium with anterolateral angles broken off, GSC 62452, x 3; GSC loc. 89288.

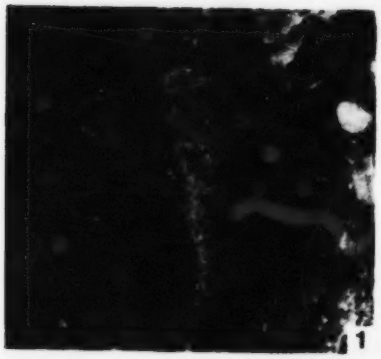
Survey Peak Formation, basal silty member

13. Fragmentary pygidium, GSC 62455, x 5; GSC loc. 92221.

Figure 6. ?*Symphysurina walcotti* Kindle, 1929

Survey Peak Formation, basal silty member

Left librigena referred questionably to the species, GSC 62450, x 5; GSC loc. 89292.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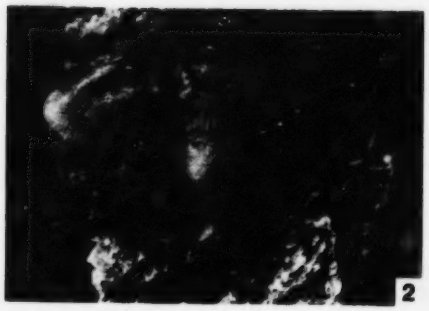
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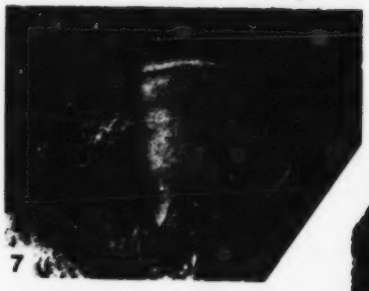
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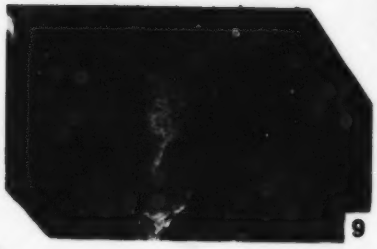
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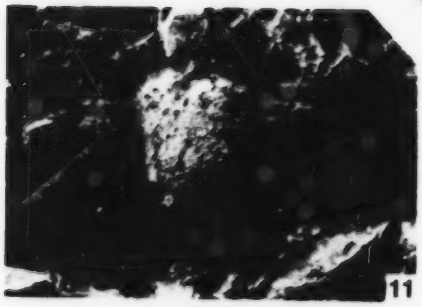
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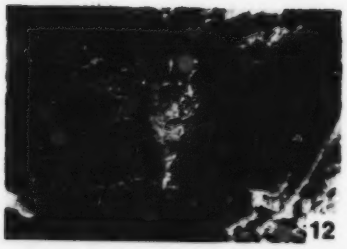
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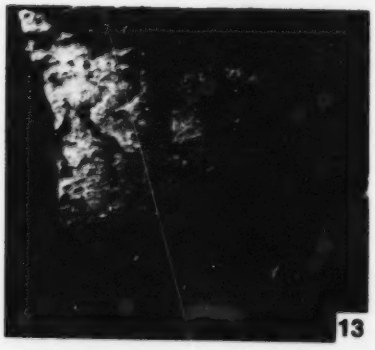
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PLATE 40

Figures 1-4, 6, 8, 12. *Bellefontia nonius* Walcott, 1925

Survey Peak Formation, middle member

1, 4, 8. Left lateral, plan, and anterior views of internal mould of incomplete cranidium, GSC 83531, x 3.5; GSC loc. 92238.

2. Latex cast of pygidium, GSC 83532, x 5; GSC loc. 92238.

3. Poorly preserved small pygidium showing impression of part of doublure, GSC 83533, x 4; GSC loc. 92238.

6. Latex cast of front of cranidium, GSC 83534, x 3; GSC loc. 92237.

12. Latex cast of incomplete left librigena, GSC 83535, x 2.5; GSC loc. 92237.

Figures 5, 9. *Kobayashia* cf. *K. douglasensis* (Walcott, 1925)

Outram Formation

Latex cast and internal mould of incomplete pygidium, showing border and small terminal spine, GSC 62456, x 3; GSC loc. 92276.

Figure 7. *Megistaspis* (*Ekeraspis*?) sp.

Outram Formation

Incomplete cranidium, GSC 62457, x 3; GSC loc. 92276.

Figures 10, 14, 15. *Peltabellia* sp.

Outram Formation

Left lateral, posterior, and plan views of incomplete pygidium, GSC 62423, x 5; GSC loc. 92284.

Figures 11, 13. *Trigonocerca*? sp.

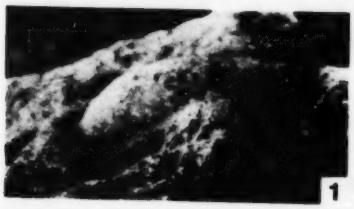
Outram Formation

Internal mould and latex cast of small pygidium with broken terminal spine, GSC 62458, x 7; GSC loc. 92275.

Figure 16. *Niobella* sp.

Outram Formation

Internal mould of incomplete cranidium, GSC 62459, x 3; GSC loc. 92279.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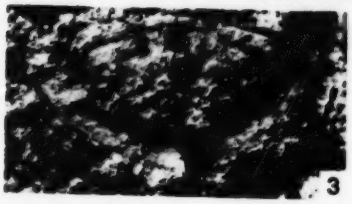
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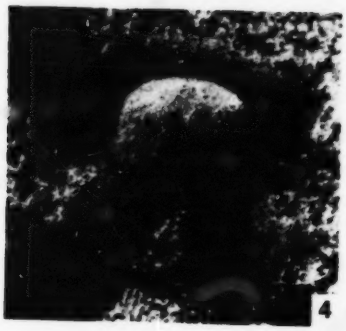
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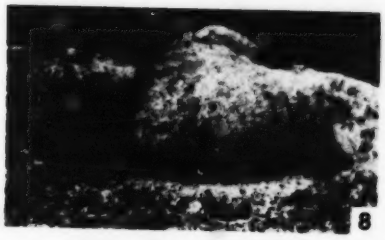
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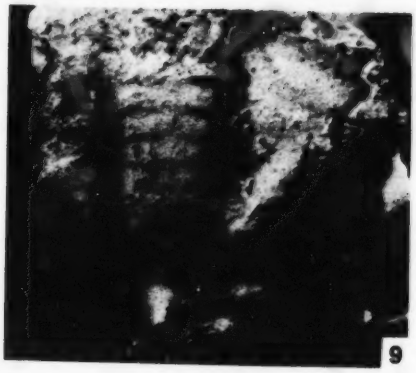
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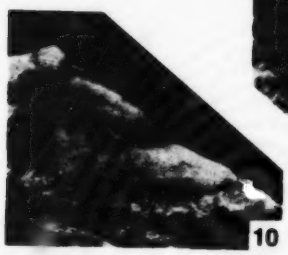
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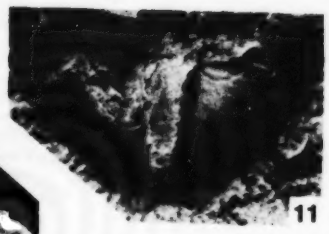
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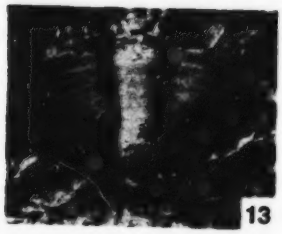
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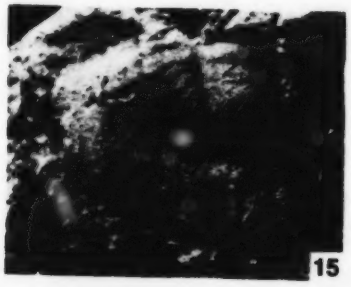
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PLATE 41

Figures 1-15(?). *Parabellefontia concinna* Hintze, 1953

Survey Peak Formation, middle member

1, 2, 4. Plan, anterior, and right lateral views of exfoliated, small cranidium, GSC 83536, x 7; GSC loc. 92237.

3, 6. Plan and posterolateral views of exfoliated pygidium, showing part of doublure with lip-like inner margin, GSC 83537, x 3; GSC loc. 92237.

5. Left librigena, with part of pitted surface preserved, GSC 83538, x 4; GSC loc. 92237.

7. Exfoliated pygidium, GSC 83539, x 2; GSC loc. 92237.

8. Latex cast of incomplete, small pygidium showing pronounced lateral border furrow, GSC 83540, x 4; GSC loc. 92237.

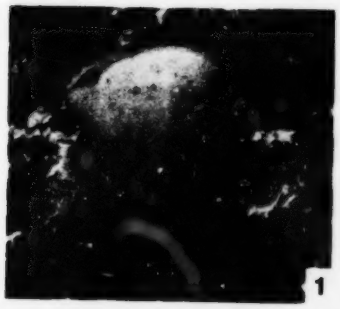
9. Incomplete, exfoliated pygidium, showing segmentation of axis, GSC 83541, x 3.5; GSC loc. 92237.

10-12. Left lateral, anterior, and plan views of incomplete cranidium, GSC 83542, x 4; GSC loc. 92237.

13. Large, almost exfoliated pygidium, GSC 83544, x 2; GSC loc. 92236.

14. Latex cast of right librigena, showing eye platform and pitted surface, GSC 83545, x 3; GSC loc. 92336.

15(?). Partly exfoliated hypostoma provisionally assigned to the species, GSC 83543, x 6; GSC loc. 92237.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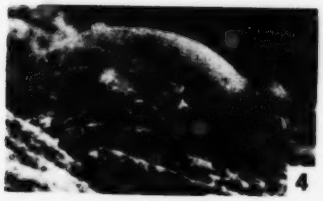
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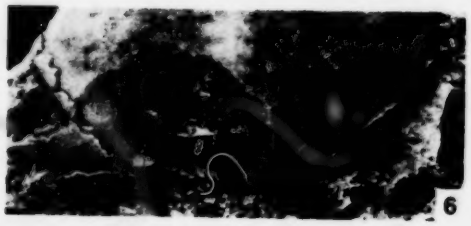
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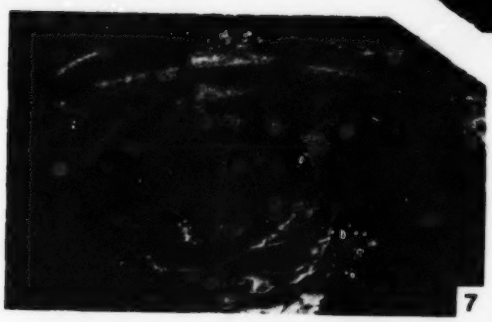
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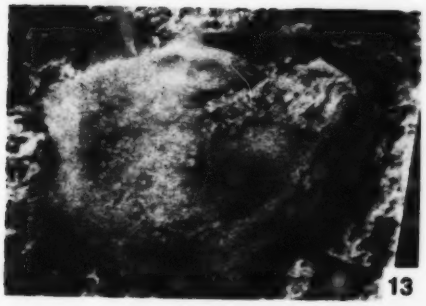
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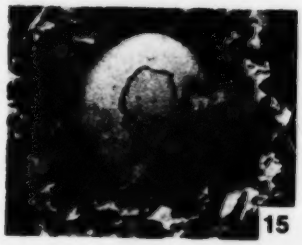
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PLATE 42

Figures 1, 5. *Leiostegium* (*Evansaspis*) *ceratopygoides* (Raymond, 1925)

"Unnamed formation" (= McKay Group), east of Harrogate, British Columbia.

Plan and posterior views of holotype pygidium (Figured by Raymond, 1925, Pl. 2, fig. 15) MCZ 1674, x 2.

Figures 2, 3, 7, 8, 10, 12. *Kainella billingsi* Walcott, 1924

"Chushina Formation" (= Survey Peak Formation), "Billings Butte" (= Extinguisher Tower), near Mount Robson, British Columbia.

2, 3, 7. Posterior, plan, and right lateral views of paralectotype pygidium, USNM 70336, x 1. (Figured by Walcott, 1925, Pl. 22, figs. 4, 5).

8, 12. Incomplete, large cranidium, lectotype, USNM 70334, x 2, x 1, respectively. (Figured by Walcott, 1925, Pl. 22, figs. 1, 2).

10. Left librigena, showing doublure, paralectotype, USNM 70335, x 1. (Figured by Walcott, 1925, Pl. 22, fig. 3).

Figures 4, 6, 14. *Apatokephalus finalis* (Walcott, 1884)

Pogonip Group, east slope of ridge next east of Hamburg Ridge, Eureka district, Nevada.

4, 6. Posterior and plan views of syntype pygidium, USNM 24563 (pars), x 2. (Figured by Walcott, 1884, Pl. 12, fig. 12a).

14. Incomplete cranidium, syntype, USNM 24563 (pars), x 2. (Figured by Walcott, 1884, Pl. 12, fig. 12).

Figures 9, 11, 13. *Kainella flagricauda* (White, 1874)

"Strata of the age of the Quebec group of Canada", Schellbourne, Schell Creek Range, Nevada.

9. Exfoliated pygidium, holotype, USNM 15452, x 4. (Described by White, 1874, p. 12; figured by White, 1877, Pl. 3, fig. 8, 8a).

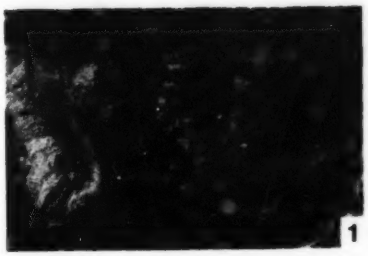
Pogonip Group, east slope of ridge next east of Hamburg Ridge, Eureka district, Nevada.

11, 13. Plan and anterior views of almost complete cranidium, USNM 24564, x 5. (Holotype of *Dicellocephalus inexpectans* Walcott, 1884, Pl. 1, fig. 10).

Figure 15. *Clelandia*? *annectans* (Walcott, 1884)

Pogonip Group, east of Hamburg Ridge, Eureka district, Nevada.

Exfoliated holotype cranidium, USNM 24571, x 6. (Figured by Walcott, 1884, Pl. 12, fig. 18).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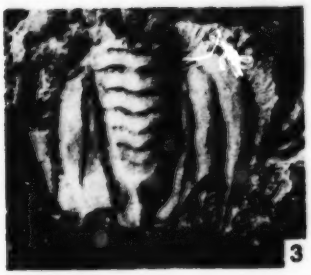
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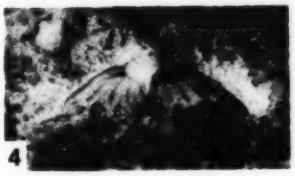
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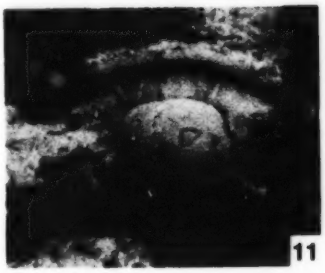
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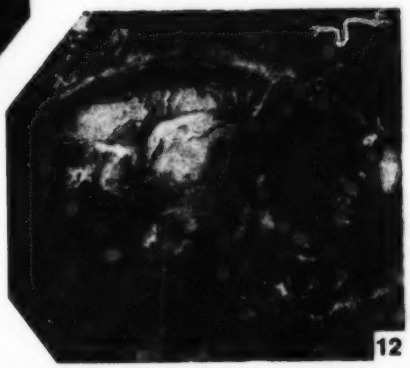
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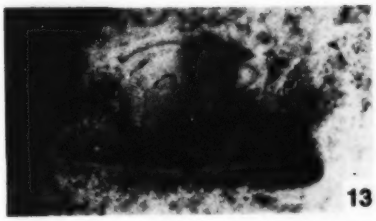
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